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USE OF MTB-100TM, PROVIDED THROUGH A MINERAL MIX, TO REDUCE TOXICITY WHEN LACTATING BEEF COWS GRAZE ENDOPHYTE-INFECTED TALL FESCUE

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DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in the College of Agriculture at the University of Kentucky

By
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Lexington, Kentucky

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2013

ABSTRACT OF DISSERTATION

USE OF MTB-100™, PROVIDED THROUGH A MINERAL MIX, TO REDUCE TOXICITY WHEN LACTATING BEEF COWS GRAZE ENDOPHYTE-INFECTED TALL FESCUE

Two experiments were conducted at the University of Kentucky, Eden Shale Farm, Owenton, KY to evaluate the use of MTB-100™ (Alltech, Inc., Nicholasville, KY) to alleviate the symptoms of fescue toxicity when lactating Angus x Beefmaster cows and their calves grazed endophyte-infected KY-31 tall fescue. Experiment 1 provided a carbohydrate based toxin adsorbent, MTB-100™, ad libitum in a commercial mineral supplement to project a daily consumption rate of 0, 20 or 40 g of MTB-100™ per cow. Cows were weighed, assigned a body condition score (BCS) and hair coat score (HC), rectal temperatures were recorded and fecal grab samples were taken for ergovaline (EV) and lysergic acid (LA) analysis every 35 days for three grazing seasons (May to September). Calves were also weighed and assigned a HC score. Although MTB-100™ did not improve cow or calf performance, cows older than 4 years and those with greater Beefmaster breeding exhibited a higher tolerance to fescue toxicity than 2 and 3-yr-olds and cows with greater Angus breeding.

Experiment 2 was conducted to evaluate the response of lactating beef cows and their calves to strategic supplementation with MTB-100™. MTB-100™ was mixed with a complete mineral so daily intake was projected to be 0 or 20 g/cow. The experimental period extended from May 5 to October 2 and was divided into 3 strategic periods: P1 = May 5 to July 5; P2 = July 5 to August 31; P3 = August 31 to October 2. Treatments were either 0 or 20 $g \cdot cow^{-1} \cdot d^{-1}$ MTB-100™ within a period (Treatment 1 = 0, 0, 0; Treatment 2 = 20, 0, 20; Treatment 3 = 0, 20, 0; Treatment 4 = 20, 20, 0; and Treatment 5 = 20, 20, 20). Cow and calf performance was measured the same as Exp. 1, but every 21 days. Supplementation early in the grazing season tended to improve cow weight gain and body condition; however, there was no effect on calf performance. Fecal output of EV and LA did not increase in either experiment with supplementation. In conclusion, strategically invoked MTB-100™ consumption can increase performance of cows grazing endophyte-infected tall fescue forage.

KEYWORDS: Cow/Calf Pairs, Ergovaline, Fescue, MTB-100^{TM}, Toxicity

Melanie Hoar____________________

Student's Signature

August 30, 2013_________________

Date

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CHAPTER I

Introduction

Many livestock species, including cattle, sheep and horses experience negative effects from fescue toxicity when grazing endophyte-infected tall fescue. Livestock producers have been dealing with problems associated with fescue toxicity for decades without finding a definitive solution. Kentucky-31 (KY-31) tall fescue is a multipurpose cool-season grass that can be found in pastures and alongside roadways and waterways, throughout the United States, due to its environmental hardiness. It is most concentrated in the southeastern region of the U.S., including states of KY, MO, AR, and TN and extending into parts of GA, NC, SC, IN, VA, OH and WV. It wasn't until after KY-31 tall fescue seed had been widely distributed that negative effects on animal performance were associated with the grass and it is in these geographical areas where the majority of fescue toxicity cases occur. Tremendous research efforts have addressed the causes, treatment and prevention of fescue toxicity. Some research focused solely on plant management, other targeted animal adaptation. One potential solution is to provide animals with a supplement of carbohydrate-based toxin adsorbent, a glucomannan developed from a yeast cell wall, to bind and prevent absorption of the toxic compounds by the animal.

The objectives of the research described in this dissertation were to:

1) Evaluate the response of lactating beef cows and their calves grazing endophyte-infected tall fescue while provided a supplemental toxin adsorbent developed from a yeast cell wall (MTB-100™).

2) Compare gradient levels of MTB-100^{TM} supplementation to reduce fescue toxicity symptoms and improve cow and calf performance.
3) Determine the optimum time to supplement cows with MTB-100^{TM} during the grazing season to alleviate the effects of fescue toxicity.

CHAPTER II

Literature Review

Background

Fescue toxicity is a major concern in the livestock industry affecting over 8.5 million beef cows and 700,000 horses (Ball et al., 1996) costing beef producers an estimated $600 million dollars annually (Hoveland, 1993).The causes of fescue toxicity, as well as different methods to reduce or alleviate its effects, have been studied extensively. Endophyte infected (E+) KY-31 tall fescue is the vehicle of the toxicity. It occupies an estimated 12 to 14 million hectares of land in the United States (Buckner et al., 1979; Thompson et al., 2001) and provides most of the nutrients needed by over 20% of U.S. beef cattle herds (West and Waller, 2007). KY-31 tall fescue is infected with a microscopic fungus first known as *Epichloë typhina* (Bacon et al., 1977), then *Acremonium coenophialum* (Morgan-Jones and Gams, 1982) and, finally, *Neotyphodium coenophialum* (Glen et al., 1996). It is called an endophyte due to its residence inside the plant. Siegel et al. (1984) found the highest concentrations of this fungus were found in the leaf sheaths and seeds. The endophyte produces ergot alkaloid compounds deemed responsible for fescue toxicosis, but the identity of specific causative alkaloids have been hypothesized and debated for years. Alkaloids are naturally occurring, organic, N-containing bases, most often produced by plants, and have many uses in medicine. Examples are morphine, quinine, atropine and vincristine (Bush and Fannin, 2009). Addictive alkaloids include cocaine, heroin, caffeine and nicotine. Loline alkaloid is a potent toxin to insects, but the peramine alkaloid is not present in large enough amounts to cause toxicity in animals (Siegel and Bush, 1996; Rowan, 1993).

Other alkaloids that will be discussed, and are the main focus of this dissertation, do have toxic effects on animals and consequently affect performance. The ergopeptine alkaloids, in particular ergovaline (EV) and lysergic acid (LA), have been named as the main contributors to the symptoms of fescue toxicity (Strickland et al., 1993; Porter, 1995). The structures of ergovaline and lysergic acid are shown in Fig. 2.1. Lyons et al. (1986) estimated EV accounts for 84 to 97% of the total ergopeptine alkaloids in the fescue. It is hypothesized ergot alkaloid compounds act as vasoconstrictors which can cause thrombosis (thickening of the blood vessel walls) by hyperplasia or hypertrophy. The resultant effect is a decrease of blood flow to the extremities, ultimately causing the symptoms of fescue toxicity (Bush et al., 1979; Thompson and Stuedemann, 1993).

KY-31 tall fescue forage production

KY-31 tall fescue is the primary cool-season grass adapted to the east-central and mid-southern United States (Hannaway et al., 2009). It is comparable in its nutritional value to other cool-season grasses regardless of the endophyte infection (Burns, 2009), but its ability to tolerate close grazing, withstand heavy animal traffic, survive drought conditions (Bouton et al., 1993), and resist insects and diseases make it more favorable than other grasses for grazing livestock (West et al., 1988). The growing season for KY-31 tall fescue begins in the cool months of spring, typically late March to May and into June, producing more than two-thirds of its annual production by late June (Roberts et al., 2009). Hannaway et al. (2009) reported optimal growing for KY-31 tall fescue occurs at 21°C ambient temperature. In the hot and dry months of the summer (July and August), KY -31 tall fescue reaches what is called a “summer slump” (Roberts et al., 2009) in which dry matter production is minimal, or can halt, depending on how long high temperatures and low rainfall persist. In late summer or when temperatures start to cool, forage production increases and peaks a second time in the autumn months and early winter (Roberts et al., 2009). This extends the grazing period and can delay the need for supplementing with hay or silage for winter feeding (Roberts et al., 2009). Bush and Fannin (2009) graphed the annual forage EV production in KY and showed it followed similar patterns to the DM production curve illustrated by Roberts et al. (2009). However, ergot alkaloid production by the *N. coenophialum* fungus is independent of KY-31 DM production. These graphs show EV accumulates in the spring and peaks in May during seed production. Agee and Hill (1994) also reported maximum production of EV in tall fescue occurs in May. They reported EV in the forage in March, April and June are 30 to 50% of the concentration found in May. During the “summer slump” of fescue production, EV concentration is very low, but begins to increase in late summer to early fall as dry matter production increases again. A second peak of EV concentration can be seen in October, illustrated by Bush and Fannin (2009), with the second substantial fescue dry matter production increase. The concentrations of EV decrease in winter months and remain low until the next year’s spring growth. These EV patterns are similar to those found by Rottinghaus et al. (1991) who studied tall fescue production in Missouri.

Biosynthesis of ergot alkaloids

The *Neotyphodium* (*N.*) *coenophialum* fungus, found in the tall fescue plant, produces the ergot alkaloids that are toxic to herbivores. Ergot alkaloids have a negative reputation throughout history causing hallucinations and convulsions in humans that may have led to the Salem witch trials in 1692-1693 as well as causing physical ailments, blisters and gangrene of limbs that was characteristic to Saint Anthony's fire in the Middle Ages (Schardl and Panaccione, 2005). These symptoms were associated with the consumption of rye bread made from ergot contaminated grain. However, ergots have been used in the pharmaceutical industry for many years and their biosynthetic pathway has been studied extensively (Schardl and Panaccione, 2005). Tryptophan and mevalonate are ergot alkaloid precursors. Dimethylallyltryptophan synthase is an enzyme and a determinant step in the ergot synthesis pathway that catalyzes a reaction between tryptophan and dimethylallyl diphosphate to create dimethylallyltryptophan (Schardl and Panaccione, 2005). Dimethylallyltryptophan undergoes subsequent oxidation/oxygenation steps and epoxidation promoting spontaneous cyclization of the third ring yielding chanoclavin-I. (Kozikowski et al., 1993). Chanoclavin-I cyclase catalyzes cyclization of the fourth ring producing agroclavine which is then hydroxylated to form elymoclavine I (Floss et al., 1974). Elymoclavine goes through oxidations to yield paspalic acid and then LA. The details of this process are illustrated in *Neotyphodium in Cool-Season Grasses* by Roberts et al. (2005). Ergopeptines are the most abundant and toxic amide derivatives of LA that are produced by the fungi *N. coenophialum* (Schardl and Panaccione, 2005). The most abundant ergopeptine is EV (Fig. 2.1) and is formed by condensation of LA (Fig. 2.1) with three amino acids alanine, valine and proline (Schardl and Panaccione, 2005).

Mutualistic relationship between ergot alkaloids and KY-31 tall fescue

The ergot alkaloids present in the seed have a mutualistic relationship with the plant and contribute to the plant's hardiness (Siegel et al., 1984). The fungal endophyte resides in the intracellular spaces of the aerial plant parts as the host provides nutrients and dissemination through the seeds (Hesse et al., 2003). The plant then benefits from the insecticidal properties, disease and improved drought resistance the fungus supplies. Ergovaline exhibits antibiosis (detrimental to the organism with which it interacts) and antixenosis (deters insects from colonizing) properties, especially in the leaf sheaths and crown, to protect against insect damage. Ergovaline is toxic to the fall armyworm larvae (Popay and Rowan, 1994) and black beetle adults which shred the base of tillers (Popay, 2004). It suppresses nematode populations by reducing weight gain and development rate of these invertebrates. Endophytes also deter insects, such as Bluegrass webworm larvae, from feeding on leaves and stems above the crown (Koga et al., 1997), the Bluegrass billbug from feeding on stems, crowns, rhizomes and roots (Richmond et al., 2000) and the chinch bug larvae from feeding near the crown (Carriere et al., 1998). Disease resistance of endophyte-infected (E+) tall fescue can be attributed the insecticidal properties of the fungus (Joost, 1995). Aphids belong to an insect family, which is highly destructive to plants. They are the primary carriers of barley yellow dwarf virus, which causes discoloration of leaves, stunting of the plant, reduced root growth, delayed heading, and ultimately reduced dry matter yield. Mahmood et al. (1993) reported the risk of disease carried by such insects is greatly reduced because of the presence of the endophytic fungus in the plant. A fungus known as leaf and sheath spot makes stand establishment difficult because it causes seedling disease (seed decay, stem lesions on seedlings and pre-emergence or post-emergence death) (Gwinn and Gavin, 1992). They found a positive linear relationship between seedling survival and endophyte infestation level. Roberts et al. (1992) concluded the disease resistance KY-31 tall fescue has exhibited could be attributed to an antifungal hydrolase protein, chitinase, which increases in the presence of the *A. coenophialum* endophyte. The insecticidal and disease resistant functions of the fungus allow the tall fescue plant to grow into healthy, thick stands, which helped the popularity of this grass with livestock producers. Unfortunately, the endophyte has been proven to be toxic to grazing animals as well.

Endophytes are not found in the root system. However, they affect root morphology and function to enhance the ability of the grass to tolerate drought by generating an extensive root system that allows water uptake from a greater volume of soil (De Battista et al., 1990). Other physiological adaptations characteristic to E+ plants are tissue protection from oxidative stress and rapid tissue regeneration after drought (Malinowski et al., 2005). The endophyte promotes active solute accumulation in cell sap which slows the loss of cell turgor in or near growing points (at the base of vegetative tillers) protecting the tissue that regenerates after drought occurs (Elmi and West, 1995). Some water saving mechanisms found in E+ fescue are stomatal closure (Elmi and West, 1995), leaf rolling (Arachevaleta, 1989), root growth modification (De Battista et al., 1990), leaf senescence and thickening of leaves and leaf surfaces (Arachevaleta, 1989). Lachno and Baker (1986) reported abscisic acid concentration, a phytohormone responsible for maintaining the water balance in plants and a regulator of stomatal function, can be increased fourfold in the roots suffering from drought stress. The presence of the endophyte increases production of abscisic acid more quickly when responding to drought stress than when plants lack the endophyte (Bunyard and McInnis, 1990). Endophyte also offers some resistance to parasitic nematodes that feed on the roots and intensify drought stress on the plant. Gwinn and Bernard (1993) hypothesized that endophyte stimulates thickening of the inner endodermal cell walls in roots making it harder for young nematodes to establish feeding sites. Drought stress promotes production of ergot alkaloids in fescue to increase the protective mechanisms preventing herbivore activity on the plant, to allow it to regenerate once the stress is over (Arechavaleta et al., 1992). This completes the cycle demonstrating the benefits of the mutualistic relationship the endophyte has with its host.

Acremonium coenophalium promotes growth of the plant by preventing excessive water uptake during imbibition which decreases germination rates (Rice et al., 1990). Endophyte-free (E-) tall fescue can be difficult to establish due to poor germination (especially in saturated areas) which results in weed competition and poor stand cover (Joost, 1995). Pinkerton et al. (1990) reported higher final germination rates in E+ genotypes compared to E- of tall fescue. Endophyte infected tall fescue has faster development of canopy heights and greater tiller formation and growth than E-. The endophyte influences the phytophormone, indoleacetic acid (Goodin, 1972; De Battista et al., 1990). Its presence promotes elongation of plant stem cells and, therefore, tillering. The presence of the endophyte allows the tall fescue to be highly competitive and persistent in nature although this can be a disadvantage if trying to rid pastures of E+ tall fescue for re-establishment with less toxic cultivars.

E+ tall fescue, E- tall fescue and NE+ tall fescue

Endophyte-free tall fescue was developed to replace E+ tall fescue by removing the fungus from the plant thus removing the causative agents of toxicity (Hoveland, 2009). The endophyte can be killed in the tall fescue seed without decreasing germination (remained at 98%) at an ambient temperature of 10° C with 19.4% moisture content (humidity) for 18 months (Welty et al., 1987). Longer storage that reduced the endophyte to 0% typically resulted in a loss of germination as well. Moisture content during the storage process must be carefully controlled; otherwise the viability of the seed is greatly decreased. Since the fungus is carried maternally (through the seed), E- cultivars are produced by planting E- seed and breeding maternal E- plants for subsequent generations (Hopkins et al., 2009). The first E- cultivar was released in 1982 in Alabama and was called Au Triumph (Hoveland, 1982). In the 1980's, E- tall fescue was extensively planted as a replacement for E+ fescue (Hopkins et al., 2009), however it did not perform up to the standards of the E+ fescue, resulting in stand loss within 3 to 5 years of establishment (Gunter and Beck, 2004). It became obvious to producers the presence of the endophyte contributed to the persistence of the plant (Hopkins et al., 2009). Stand loss of E- pasture grasses was credited to biotic and abiotic factors such as insects, drought conditions and disease. Hardy et al. (1986) found, in a laboratory study, fall armyworms preferred to feed on E- tall fescue over E+ and larvae survival was significantly less on E+. Another disadvantage of E- tall fescue was attributed to it being easily overgrazed and unable to withstand animal traffic as well as E+ fescue (Bouton et al., 1993). The ability of E+ tall fescue to withstand animal traffic could be a result of fescue toxicity effects on grazing animals preventing them from grazing under heat stress conditions; whereas animals grazing E- fescue do not suffer from the toxicity effects and can graze longer (Joost, 1995). Cattle grazing E- fescue pasture spent more time grazing during the day while cattle on E+ pasture grazed more at night (Coffey et al., 1992). Parish et al. (2003) observed cattle grazing E+ fescue spent less time grazing, more time idling and standing and drank more water than cattle grazing E- fescue and novel endophyte fescue. Dry matter intake was 24 to 44% lower for cattle grazing E+ tall fescue compared to cattle grazing E- tall fescue (Stuedemann et al., 1989). Howard et al. (1992) found steers grazing E- tall fescue spent more time grazing, less time lying down and took more prehensile bites during the day than steers on E+ pasture. The steers on E+ pastures spent more time standing and idling, instead of grazing, during the heat of the day and did not graze more during the night than steers grazing E- fescue. This suggests the reduction of dry matter intake by cattle consuming E+ fescue reduces the amount of grazing pressure on E+ fescue pastures compared to E- pastures and could contribute to the weight loss experienced by cattle consuming E+ forage. Despite the low persistence of E- tall fescue, cattle grazing E- cultivars perform better than those cattle grazing E+ tall fescue (Hoveland, 2009; Gunter and Beck, 2004). If E- fescue is produced under irrigated conditions (Asay et al., 2001), soil with good water holding capacity (Hopkins and Alison, 2006) and optimal climates (Brummer and Moore, 2000), E- fescue can be used as an alternative to E+ because plant stress is minimized (Hopkins et al., 2009).

For those areas unsuitable for E- tall fescue to thrive, such as sandy soils and drought conditions, producers have sought another alternative. "New" or "novel" endophytes that contribute to the plant's hardiness, without inducing toxicity symptoms in grazing livestock, were discovered and integrated into a novel-endophyte-infected (NE+) tall fescue cultivar. Naturally occurring, nontoxic endophyte strains were isolated and used to re-infect the best available cultivars (Bouton and Hopkins, 2003). Gunter and Beck (2004) reported a new endophyte (AR542) that lacked ergot alkaloids was discovered and isolated in New Zealand. This particular strain was reinfected in Jesup tall fescue cultivars (Bouton et al., 1997). It is marketed in the U.S. as Jesup MaxQ and is the main commercial "novel" product available (Rolston and Agee, 2007). Bouton et al.

(2002) found lambs grazing AR542 and E- pasture had greater gains, higher blood serum prolactin levels and lower body temperatures ($P < 0.05$) than lambs grazing E+ pasture. Other studies showed cattle grazing NE+ tall fescue cultivars have comparable gains to those grazing E- pastures without the loss of stand (Gunter and Beck, 2004).

Before replacing E+ pastures with E- or NE+ tall fescue, many factors must be considered. Pastures chemically treated to remove E+ tall fescue will not produce feed for several months up to a year, which will impact herd size and maintenance (Fribourg and Milne, 2009). In steep areas, measures have to be taken to prevent soil erosion (Carreker et al., 1977). Geographic region should be taken into consideration before choosing a specific cultivar, such as E- fescue. If re-seeding with NE+ cultivars, seed storage must be carefully controlled so the novel endophytes stay viable (Fribourg and Milne, 2009). The University of Arkansas Cooperative Extension Service developed a procedure for establishing a new pasture with E- or NE+ without E+ contamination (Boyd, 1993). The procedure consists of spraying the E+ pasture with the herbicide, glyphosate, in the early spring before heading. Secondly, no-till plant a summer annual crop (pearl millet or sorghum-sudangrass) for hay production during the summer. Then smother any emerging tall fescue plants by spraying any regrowth with glyphosate after the final cutting of hay. No-till drill E- or NE+ seed into summer annual crop stubble in the fall, apply fertilizer at seeding or after seedlings are up. Finally, apply ammonium nitrate the following spring. It is possible volunteer E+ fescue seed or seed from surviving crowns and roots could try to re-establish the area so it is important to make sure the chemical treatment covers the entire pasture and any thriving spots need to be controlled (Fribourg and Milne, 2009). Tall fescue pastures that are re-seeded can be cut for hay during May to July of the first year after establishment in the previous fall (Gunter and Beck, 2004). These workers estimated the total cost for this procedure to be $988.66/ha. Based on their return estimates, it would take 3 to 7 years to pay for the establishment costs.

Pasture management to reduce fescue toxicity when grazing livestock on E+ tall fescue

Different management practices have been used on E+ tall fescue to reduce exposure to fescue toxicosis and, thereby, increase animal performance. These practices include diluting the pasture with legumes such as clover, delaying the grazing of stockpiled tall fescue, increasing grazing pressure to reduce seedhead formation, using a plant growth regulator to retard seedhead formation, clipping or mowing to reduce seedheads, rotational grazing, providing a creep diet for calves and switching from E+ fescue pasture to another type of grass pasture in the hottest months of the summer (Paterson et al., 1995; Stuedemann and Seman, 2005; Waller, 2009). Decreasing the amount of N and P in fertilizer also improves animal performance. Fertilizing E+ pasture with poultry litter, or other high N fertilizers, increases the amount of forage ergot alkaloids and, as a result, increases the occurrence of fescue toxicity (Stuedemann and Seman, 2005). Rottinghaus et al., (1991) found increasing N fertilizer from 0 to 135 kg/ha increased EV by 88, 103 and 66% in leaf blades, stems and seedheads, respectively. High P fertilizers have also been shown to increase ergot alkaloid synthesis when applied to P deficient soils (Stuedemann and Seman, 2005). The management practices mentioned may reduce the incidence of fescue toxicity and improve animal performance, however, they may not completely eliminate its symptoms.

Symptoms associated with fescue toxicity

Fescue toxicosis in beef cattle is identified by three disorders: fescue foot, bovine fat necrosis and summer slump. The characteristics of fescue foot are lameness, red or flushed color around the coronary band of the hoof, knuckling of the pastern joint, arching of the back, shifting from one back foot to the other, gangrene and eventually sloughing of hooves, tips of ears or tailhead (Bush et al., 1979). These symptoms are typically seen in winter months under extreme cold temperatures. Fat necrosis is caused by hardened fat around the gastrointestinal tract resulting in digestive and reproductive problems (Bush et al., 1979). This disorder is not discovered until post-mortem examinations. Stuedemann et al. (1985) reported this symptom is less common than others. They also found it was more common when high levels of N fertilizer were applied in the spring of the year. Symptoms of summer slump include: rough hair coats, decreased weight gain, decreased milk production and conception rates, heat intolerance causing excessive salivation, elevated body temperature and increased respiration rate (Bush et al., 1979; Crawford et al., 1989; Garner and Cornell, 1978; Hoveland et al., 1983; Stuedemann and Hoveland, 1988) These symptoms are amplified by high ambient temperatures and high humidities in the mid to late summer months.

Other species of livestock suffer from fescue toxicity although symptoms may vary. Although only 1.4% of the sheep population in the U.S. grazes tall fescue pastures (West and Waller, 2007), they are used as ruminant models in research due to their relatively small body size and ease of management in a laboratory environment. As with cattle, milk production is decreased in ewes (Stidham et al., 1982), serum prolactin is reduced (Bond et al., 1988), lambs gain slower (Parish et al., 2003) and rectal temperatures are elevated (Hannah et al., 1990) when consuming E+ tall fescue. Delayed onset of estrus and increased embryonic mortality are also problems for ewes grazing E+ tall fescue (Bond et al., 1988). However, ewe productivity, gestation length, average number of lambs born, lamb birth weight and lamb survival do not appear to be affected by E+ tall fescue forage consumption (Bond et al., 1988). On the other hand, mares seem to be highly sensitive to endophytic fescue and exhibit prolonged gestation lengths, abortions, thickened placentas, dystocia, poor milk production, agalactia and increased rate of stillborn foals (Monroe et al., 1988). However, removing pregnant mares from tall fescue pasture 30 to 40 days before foaling can greatly reduce the effects of endophytic forage consumption (Taylor, 1993).

Effects of endophyte on reproduction and milk production

Although the effects of endophyte on bulls have not been extensively studied, Schuenemann et al. (2005a) conducted a study with yearling bulls fed ergotamine tartate to imitate fescue toxicity. The bulls receiving the ergotamine exhibited decreased animal performance (decreased weight gain) and increased rectal temperatures compared with the control. Other evidence from this study indicated bulls exposed to the ergot alkaloids had reduced fertilization potential. In a second study, Schuenemann et al. (2005b) determined bulls consuming E+ tall fescue had a decreased scrotal temperature, which may have been caused by vasoconstriction. Looper et al. (2009) compared Brahman-influenced bulls grazing E+ or E- tall fescue pastures to determine if ergot alkaloids had an effect on sperm characteristics (motility and morphology) and serum concentrations of prolactin, cortisol and testosterone. They found no difference between the two treatments for body weight changes, rectal temperatures, scrotal circumference, percentage of live sperm and cortisol and testosterone levels. Although it was not significant, the percentage of live sperm for bulls grazing E+ tall fescue pasture was 67% compared to those on E- pasture (80%). Bulls grazing E+ pasture also had decreased prolactin concentrations and reduced sperm motility and morphology in July and August of the grazing season when average maximum daily ambient temperatures were 33.6 and 39.7°C, respectively. Sperm motility was not affected in May and June. They concluded semen quality of bulls grazing E+ tall fescue pastures decreased with increased maximum ambient temperatures. Stowe et al. (2013) fed bulls E+ tall fescue seed to evaluate the impact of ergot alkaloid consumption on growth, scrotal circumference and semen quality. They found neither weight nor BCS of bulls was affected by the consumption of the E+ diet. Bulls ingesting E+ tall fescue seed did experience decreased prolactin concentration and reduced scrotal circumference, yet semen quality was not affected.

The economic success of a beef cow/calf operation relies on the cow to produce and raise a live calf annually. The majority of the 14 million hectares of tall fescue in the U.S. is grazed by cow/calf pairs (Paterson et al., 1995). Cows grazing E+ fescue tend to lose more weight, have decreased pregnancy rates and milk production and wean lighter weight calves in comparison to those grazing E- fescue (Paterson et al., 1995). Schmidt et al. (1986) reported cows that consumed E+ fescue had a pregnancy rate of 55% compared with a 96% for those that consumed E- fescue. Low conception rates may be partially due to endophyte induced weight and BCS loss (Paterson et al., 1995). Schuenemann et al. (2005c) conducted reproduction studies with beef cows and found problems associated with pregnancy and fescue toxicity occurred between the release of the mature follicle and the first 6 days of embryonic development. Endophyte induced vasoconstriction could reduce blood flow and, therefore, hormones to internal organs and could have an effect on reproduction (Porter and Thompson, 1992). Ergot alkaloids are capable of inhibiting egg implantation in the female, have embryotoxic effects and can stimulate uterine contractions leading to spontaneous abortions (Berde and Schild, 1978).

As mentioned previously, milk production is depressed when cows consume E+ tall fescue. Decreased blood flow to the mammary gland, due to endophyte induced vasoconstriction or decreased feed intake by heat stressed cows resulted in limited nutrient availability for milk production (Porter and Thompson, 1992). Prior to lactation, prolactin secretion is important for mammary gland differentiation, a necessary step for milk synthesis (Ackers et al., 1981). Therefore, it is possible for cows consuming E+ tall fescue prior to parturition to exhibit decreased milk yield due to decreased blood serum prolactin. Prolactin is not involved in galactopoiesis or the maintenance of lactation, (Karg and Schams, 1974), so consumption of E+ tall fescue by cows postpartum should not have an effect on milk yield. Peters et al. (1992) conducted a study in which cow/calf pairs grazed E+ tall fescue, orchardgrass (OG) or E- tall fescue from May to September. Cows grazing E- performed similarly to those on OG, but cows consuming E+ tall fescue produced 25% less milk than those grazing E- and OG. This work supported Danilson et al. (1986) who concluded milk production declines 0.15 kg/d for each 10% increase in forage endophyte infestation. Decreased milk production by cows consuming E+ tall fescue resulted in decreased weaning weights of calves (Peters et al., 1992). Rutledge et al. (1971) estimated milk production of beef cows accounted for approximately 60% of the variance in calf weaning weight. Bernard et al. (1993) fed E+ and E- tall fescue to prepartum dairy cows and did not find a difference in milk yield between treatments, however, all milk constituents, especially fat was numerically lower for E+ cows. If the same is true for beef cows, a negative effect on calf performance may occur because of milk composition and/or reduced milk production.

Thermoregulation of cattle consuming E+ tall fescue

Severity of fescue toxicosis is conditional upon the environment and thermal stress. Symptoms are intensified by extreme ambient temperatures and humidity so the minimum level of ergot alkaloids required to trigger disease is lowered under these extremes (Hemken et al., 1981). Symptoms of “summer slump” are more severe for cattle when ambient temperatures exceed 32°C and humidity is especially high (Hemken et al., 1981; Porter and Thompson, 1992). Hemken et al. (1981) found dry matter intake, weight gain, rectal temperature and respiration rates were not affected when Holstein calves consumed E+ tall fescue at low (10 to 13°C) and medium temperatures (21 to 23°C). However, at high temperatures (31 to 35°C), calves consuming E+ tall fescue had lower dry matter intakes and weight gains and higher rectal temperatures and respiration rates than calves fed OG or E- tall fescue. For environmental temperatures to play a role in animal response to the presence of endophyte, the animal’s ability to regulate body temperature must be affected (Spiers et al., 2005). Homeothermy is the maintenance of a constant body temperature in different thermal environments and is achieved by balancing heat production and loss (IUPS Thermal Commission, 2001). The thermoneutral zone is the area between two critical limits (lower and upper) at which the minimum amount of energy is expended by an animal to maintain homeothermy. The lower critical limit is the ambient temperature below which the animal has to increase its metabolic rate to maintain heat balance (IUPS Thermal Commission, 2001). The upper critical limit is the ambient temperature above which the animal must increase evaporative heat loss to maintain heat balance (IUPS Thermal Commission, 2001). Endophytes can alter the thermoneutral zone of animals by their constrictive effects on peripheral blood vessels. Because peripheral vasoconstriction in animals decreases heat dissipation in animals, consumption of E+ tall fescue can induce hyperthermia (Spiers et al., 2005). In a typical environment (without the presence of endophytes) blood vessels constrict in colder temperatures to maintain normal core body temperature. In hot temperatures, blood vessels should dilate to allow heat to be released from the peripheral tissues to cool down the core temperature. When under the influence of endophytes, the animal loses control of thermoregulation and blood vessels constrict causing hyperthermia in the summer and hypothermia in the winter. After injecting EV in cattle exposed to a heat stressed environment (31°C), core body temperature and respiration increased, and skin temperature of the hip, back and tail decreased suggesting reduced blood flow to the extremities (Al-Haidary et al., 1993; McCollough et al., 1994). Animal age, breed and species are major determining factors of the critical limits of the thermoneutral zone and, therefore, how animals respond when subjected to E+ tall fescue (Spiers et al., 2005).

Some heat resistant breeds of beef cattle, such as the Brahman or Senepol, demonstrate better performance while grazing E+ tall fescue compared to Angus and Hereford breeds (Brown et al., 1992; Browning, 2004). Browning (2000) injected an ergotamine compound intravenously into Brahman and Hereford steers and produced similar toxicity responses by both breeds. The findings indicate heat tolerant and heat sensitive breeds of cattle are susceptible to fescue toxicity, but, the environment plays an important role in how each responds. When consuming E+ fescue during heat stress, Brahman breeds had a smaller reduction in daily weight gain (McMurphy et al., 1990) and milk yield (Brown et al., 1993). Brahmans are more heat tolerant and have a different upper and lower critical temperature (thermoneutral zone) so it is expected they would experience heat stress at higher temperatures than heat sensitive breeds (Spiers et al., 2005). However, Kerr and Kelch (1999) concluded they would also be more likely to develop gangrene of the extremities in cold weather. Crossing a heat resistant breed of cattle and one that is heat susceptible may improve tolerance of endophyte toxicity, but it will not overcome all production losses when grazing E+ tall fescue (Stuedemann and Seman, 2005). Genetic selection has potential to influence performance of cattle grazing E+ tall fescue, but it is not a solution to eliminate all the effects of fescue toxicity.

Ergot alkaloid induced vasoconstriction

Serotonin, epinephrine and norepinephrine are biogenic amines synthesized from tyrosine and function as neurotransmitters for many biological processes (Widmaier et al., 2008). One function of these biogenic amines is naturally induced vascular smooth muscle cell growth (hyperplasia) resulting in a decrease of the blood vessel lumen. These amines cause vasoconstriction in response to cold ambient temperature. Alkaloids produced by the endophyte in tall fescue interact with the biogenic amine receptors (α-2-adrenergic and serotonin-2) on the smooth muscle surrounding the blood vessels to produce similar effects as serotonin, epinephrine and norepinephrine (Strickland et al., 1996). Serotonin-2 receptors can be stimulated by ergot alkaloids to trigger mitogenesis which increases cell numbers (Oliver, 1997). This causes blood flow to be restricted to peripheral tissues resulting in the inability of the animal to dissipate heat, and in severe cases, tissue death. Epinephrine and norepinephrine bind to α-2-adrenergic receptors on vascular smooth muscles. Ergot alkaloids stimulate these receptors to enhance blood platelet aggregation causing coagulopathies (clotting disorders) and hypoxia (oxygen deprivation) resulting in tissue necrosis (Oliver, 1997). Increased respiration rates can be caused by hypoxia in cells in addition to releasing body heat. Foote et al. (2012) concluded EV is the primary ergot alkaloid responsible for peripheral vasoconstriction of blood vessels. Lysergic acid also produces a contractile response in the bovine lateral saphenous vein (Klotz et al., 2008), however, EV is 1,000 fold more potent (Klotz et al., 2006, 2007). Ergot peptide alkaloids, such as EV and LA, have an ergoline ring structure (Fig. 2.1) they share with the biogenic amines norepinephrine, dopamine and serotonin (Berde, 1980). The structural similarities allow ergot alkaloids to stimulate or antagonize biogenic amine receptors causing problems with thermoregulation and vasoregulation (Floss et al., 1973).

Ergot alkaloids and their influence on hormonal regulation

Serum prolactin levels decrease in animals suffering from fescue toxicity. Boling et al. (1989) surmised the level is independent of environmental conditions. Berde and Schild (1978) reported ergot alkaloids decrease prolactin through dopaminergic and antiserotonergic activities by binding to the dopamine receptors. Secretion of prolactin occurs in the anterior pituitary and is regulated by secretion of dopamine from the hypothalamus (Leong et al., 1983). Dopamine is carried down the stalk median eminence of the hypothalamus to the hypophyseal stalk which connects to the anterior pituitary. It binds to dopamine receptors (lactotrophs) on the anterior pituitary membranes (Leong et al., 1983). In the anterior pituitary, prolactotrophs contain large secretory granules which store releasable pools of prolactin and other hormones. Schillo et al. (1988) suggested that endophyte toxins decrease the releasable pools of prolactin by suppressing prolactin synthesis. This suggestion was based on findings of Maurer (1981) that the ergopeptide, ergocryptine, reduced prolactin gene transcription of cultured rat prolactotrophs. Schillo et al. (1988) also suggested ergot alkaloids can cross the blood brain barrier and directly affect hormone levels of prolactin and dopamine in the anterior pituitary, thus, altering neurotransmitter systems. In contrast, administration of dopamine antagonists (as haloperidol, phenothiazine, domperidone, metoclopramide and spiperone) can reverse prolactin suppression (Boling, 1989; Bolt, 1983). Although, dopamine antagonists have increased prolactin levels, other studies have shown varying results for improving the animal's ability to dissipate body heat and increasing blood flow, average daily gain and grazing time during the heat of the day (Paterson et al., 1995).

Photoperiod influences circulating prolactin concentrations, which are highest in light and lowest in dark periods (Tucker and Ringer, 1982). The opposite is true for another neurohormone, melatonin. It is synthesized in the pineal gland and can antagonize prolactin release (Reiter, 1981). Melatonin is synthesized from serotonin, but synthesis and secretion from the pineal gland is also dependent on photoperiod. Dopamine may play a role in converting serotonin to melatonin in the pineal gland, which, in turn, may determine how the animal responds to changing seasons (Heldmaier and Lynch, 1986). If dopamine increases the conversion of serotonin to melatonin and melatonin decreases prolactin levels, this may explain how endophytes interfere with reproduction in certain animals. For example, most female sheep breeds are seasonal breeders meaning they depend on photoperiod triggers (day length and environmental temperature in the Northern Hemisphere) to exhibit estrous activity. Typical breeding season for ewes is in the fall (September to November) and when the hours of daylight become fewer. The delayed onset of estrus in ewes consuming E+ tall fescue could be a result of endophytes interfering with the neurohormones, prolactin and melatonin, which normally would respond to the photoperiod.

Serotonin-2 receptors are located in the central nervous system as well as the vascular smooth muscle. In the central nervous system, serotonin binds to the serotonin -2 receptors to control the release of neurotransmitters and hormones including dopamine, epinephrine, norepinephrine and prolactin (Floss et al., 1973). Neurotransmitters and hormones influence biological and neurological processes like thermoregulation and behavior such as aggression, anxiety, appetite and sleep (Widmaier et al., 2008). Cattle grazing E+ tall fescue have exhibited increasing levels of serotonin metabolites which increase body temperature and suppress appetite (Oliver, 1997). Therefore, animals grazing E+ tall fescue may spend more time in shaded areas than those grazing E- due to behavioral issues associated with hormonal imbalance caused by ergot alkaloids interfering with receptors in the brain.

Absorption and elimination of ergot alkaloids

The physiological aspects of digestion and absorption of ergot alkaloids are not well defined. Hill et al. (2001) demonstrated ergot alkaloids can be transported across the ruminal and omasal wall. Hill et al. (2001) also reported LA was absorbed in the greatest quantity compared with ergonovine, ergotamine, and ergocryptine. But, LA was found to be the only ergot alkaloid to cross ruminal and omasal walls. Other studies have found ergot alkaloids in serum, urine, bile, ruminal and abomasal fluids, and feces of cattle, sheep and horses (Strickland et al., 2009). Westendorf et al. (1993) fed E+ fescue to abomasally cannulated sheep and found pyrrolizidine alkaloids were converted, by the rumen microbes, into loline. Recovery of dietary loline alkaloids averaged 5% from abomasal contents, but 0% from the feces. In the same experiment, 50 to 60% of the ergot alkaloids (EV and ergovalinine) in the diet were recovered in the abomasal contents, but only 6 to 7% in the feces. Therefore, the site for absorption of ergot alkaloids appears to be in the lower portion of the gastrointestinal tract. When steers were switched from an E- to an E+ pasture, they had only 33% as many urinary alkaloids, after 12 hours of grazing, as those continually grazing E+ tall fescue (Steudemann et al., 1998). After 24 hours, urinary alkaloid levels were the same. Twenty-four hours after switching steers back to E- tall pastures, ergot alkaloid concentrations in the urine decreased 66% and were completely eliminated from the urine after 96 hours. The authors of this publication concluded ergot alkaloids are liberated from the plant by microorganisms in the rumen, absorbed rapidly from the digestive tract and can be LA amines or transformed into ergot alkaloid derivatives and excreted in the urine or bile. They also reported 96% of the ergot alkaloids were excreted in the urine, but the excretion route may be altered by molecular weight. Those alkaloids under 350 Da were excreted in the urine, those between 350 to 450 Da were excreted in urine and bile, and those weighing more than 450 Da were excreted in the bile (Stuedemann et al., 1998). Transformation of the ergot alkaloids into derivatives, such as LA, occurs by opening the tricyclic amino acid ring structure at proline, changing the nonpolar molecule to polar and this byproduct is then excreted in the urine (Stuedemann et al., 1998). Nimmerfall and Rosenthaler (1976) used bile duct cannulated Wistar rats and Rhesus monkeys to study the elimination routes of ergot alkaloids (dyhydroergocristine mesylate, dihydroergotamine mesylate or ergotamine tartrate). Results showed bile to be the primary route of excretion for these compounds weighing over 600 Da. Endophyte infected tall fescue seed was fed to geldings to identify elimination routes of EV and LA in the horse (Schultz et al., 2006). Lysergic acid was excreted primarily in urine and to a lesser extent in the feces. Only 35 to 40% of the total EV consumed was excreted in the feces, but none was detected in the urine. Strickland et al. (2009) suggested the negative balance from the diet to the feces indicates EV, and possibly other alkaloids, may be biotransformed into LA before it is excreted. Based on gastrointestinal disappearance and excretion rates of ergot alkaloids in these experiments, it appears the majority of ergot alkaloids bypass the forestomach of ruminants and are absorbed in the intestines. Ergot alkaloids that do not bypass the rumen are degraded by rumen microbes into derivatives, such as LA, and are absorbed in the hindgut. Depending on the size of the alkaloid, excretion may also occur through the bile or the urine. Further research is needed to pinpoint the site and methods of absorption of ergot alkaloids.

Other research

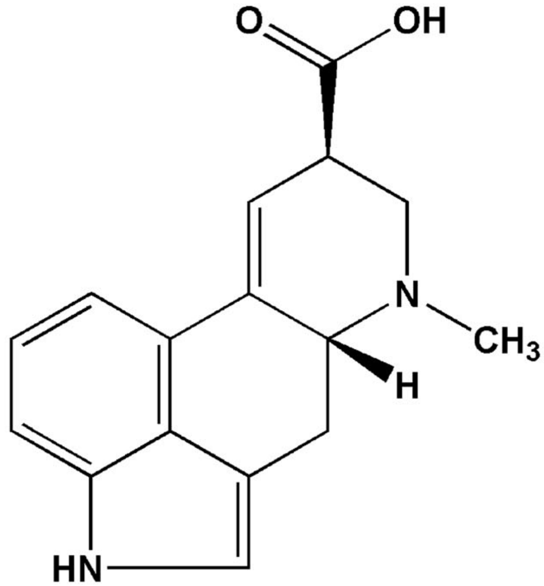
If the problems of toxicity can't be solved by changing or replacing the existing infected fescue plant, then alternative solutions must be found by targeting animal response to the fescue. Waller (2009) reviewed several practices that target animal response: supplementing with thiamin or copper, protein supplementation, estrogenic implants, administering a dopamine antagonist and feeding seaweed. Another method was developed by Alltech, Inc. Nicholasville, Ky. The product was first called Mycosorb, then FEB-200™, MTB-100™ and the current name, Integral. These names are used interchangeably in the literature review when referencing other research. The product is a glucomannan or the cell wall component of the yeast *Saccharomyces cerevisiae*. Theoretically, the product binds mycotoxins in vivo for excretion in the feces. The yeast cell wall is composed of protein and carbohydrates (glucose, mannose and N-acetyglucosamine) and has been studied extensively for binding in vitro and in vivo. Rumen bacteria are unable to use the yeast cell wall as a carbon source making it indigestible and ideal as a toxin binding agent (Evans and Dawson, 2007). These researchers demonstrated Mycosorb can bind as much as 40% of the ergopeptide ergotamine in rumen fluid.

In vivo studies using the glucomannan product to improve animal performance have produced varying results. Aaron et al. (2004) showed weight gains, BCS and tympanic temperatures of beef cows and weight gains of calves grazing pastures of E+ tall fescue were improved when FEB-200™ was added to a corn supplement fed to cows once daily. Mills (2007) fed 20 g MTB-100™/d, in a soybean hull supplement, to beef calves grazing E+ tall fescue pastures. No supplementation effect was found for weight gain, fecal ergot alkaloid output or serum prolactin concentration. However, tympanic temperature was lower for the supplemented calves, which supported the findings of Aaron et al. (2004). Merrill et al. (2007) added gradient levels (0, 20, 40 or 60 g/d) of MTB-100™ through a soybean meal-trace mineralized salt supplement, fed intraruminally, to cannulated steers consuming E+ tall fescue straw. In a second study, they fed the same levels of MTB-100™ in a soybean meal supplement to beef cows consuming E+ tall fescue straw. The goal of these experiments was to determine the influence of MTB-100™ on forage intake, digestibility, ruminal fermentation characteristics, serum prolactin, prolactin stores, symptoms of fescue foot and milk production in beef cattle during late fall and winter. None of the animals exhibited symptoms of fescue toxicosis. Ruminal characteristics, serum prolactin, fecal EV or LA excretion, DMI and OM were not affected by increasing glucomannan supplementation. However, prolactin stores increased with increasing supplementation level. In the second study, Merrill et al. (2007) reported MTB-100™ had no effect on DM, OM or NDF digestibilities as well as ruminal ammonia levels, pH or total VFA concentration. MTB-100™ supplementation did not affect weekly serum prolactin concentrations, weight changes or BCS, although milk production and prolactin stores in cows increased with MTB-100™ supplementation levels. Another study used the glucomannan, FEB-200™, in a liquid supplement provided to steer calves on pasture from May to August (Gunter et al., 2009). Treatments were 1) unsupplemented 2) provided a liquid supplement (lick-wheel feeders) without the glucomannan or 3) provided a liquid supplement with the glucomannan for a projected daily intake of 10 to 20 g of FEB-200™ per steer. Unsupplemented steers and liquid supplemented (with or without the glucomannan) steers did not differ in body weight throughout the study. From day 29 to 56 during the 133-day study, liquid supplemented (with or without glucomannan) steers gained more weight (32% faster) than unsupplemented. Over the 133 day study, those receiving the liquid supplement containing glucomannan gained 33% more weight than those on liquid supplement without the glucomannan. Prolactin levels were not influenced by supplementation. Steers in the unsupplemented treatment spent more time grazing than those in both liquid supplement treatments. The authors explained the amount of time supplemented steers spent at the lick-wheel may have substituted for the amount of time they could have spent grazing and thus might explain why there was no difference in body weight between unsupplemented and liquid supplemented steers. Time spent at the lick-wheel was similar between liquid supplemented treatments. However, steers receiving the glucomannan in the liquid supplement, spent 17% and 11% more time grazing in June and July respectively. This may account for the higher ADG between days 29 and 56 for steers receiving the glucomannan versus those receiving only the liquid supplement. Gunter et al. (2009) concluded FEB-200™ had a positive effect on animal performance through increasing the amount of grazing time and therefore DMI.

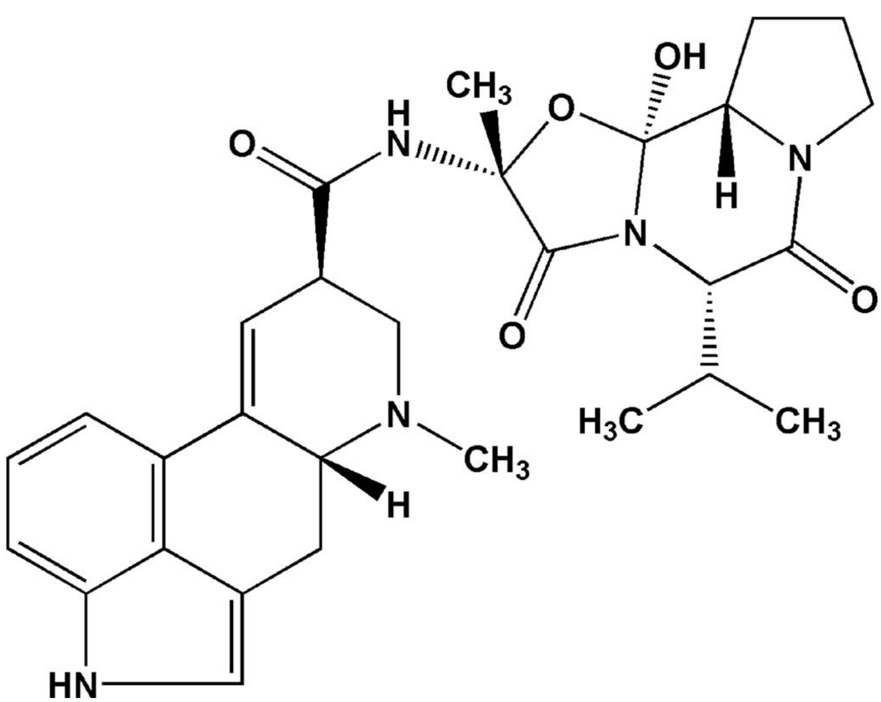
As evidenced by the literature, supplementing beef cattle with a glucomannan has exhibited a variety of results. These studies indicate the use of a glucomannan product has potential to alleviate some symptoms of fescue toxicity. Research needs to be conducted to determine the most efficient method and level of glucomannan supplementation and at what point during the grazing period is supplementation most beneficial.

Figure 2.1. Chemical structures of A) lysergic acid and B) ergovaline.[1]

A



B



[1] Adapted from Klotz et al. (2008).

CHAPTER III

Experiment 1: Supplementing gradient levels of MTB-100^{TM} in a complete mineral mix provided ad libitum to lactating beef cows grazing endophyte-infected tall fescue.

Introduction

Supplementing with a glucomannan, such as MTB-100^{TM}, in corn fed daily to beef cows has been shown to improve performance when cows and calves graze endophyte-infected tall fescue. Cows supplemented with the glucomannan, FEB-200^{TM} also marketed as MTB-100^{TM}, maintained heavier weights, higher BCS, had lower tympanic temperatures and weaned heavier calves than those unsupplemented (Aaron et al., 2004). However, feeding corn daily to a herd of mature cows, when pasture is providing enough forage to meet their nutritional needs, can be expensive and, therefore, is impractical for producers. Incorporating glucomannan in a mineral mix that is provided ad libitum may be a more feasible approach for producers. Also, level of supplementation required to produce the most economical positive response must be determined. Therefore, the objective of this study was to evaluate the response of lactating beef cows and their calves to gradient levels of a nutritional supplement produced from a carbohydrate based toxin adsorbent (MTB-100^{TM} Alltech, Inc.) when grazing endophyte-infected KY-31 tall fescue.

Materials and Methods

The experimental protocol was approved by the Institutional Animal Care and Use Committee at the University of Kentucky.

Study 1: Herd-managed cow/calf pairs

This experiment was conducted at the University of Kentucky Eden Shale Research Farm in Owenton, KY. One hundred and seven, Angus and Angus x Beefmaster cows and their spring-born calves (born in February and March) were randomly assigned to nine, 10.5-ha, endophyte-infected (> 90%) pastures, stocked with 10 to 16 cow/calf pairs each at the start of the grazing season and re-randomized each year of three. The experimental timeline is shown in Fig. 3.1. The grazing season began on May 8 and concluded when calves were weaned on September 15. These nine pastures were randomly allotted to three treatments (re-randomized each year). MTB-100^{TM}, was mixed with mineral so projected intakes were 0, 20 or 40 g MTB-100^{TM}•cow^{-1}•d^{-1}. The mineral mixes, containing corn oil, white salt and MTB-100^{TM} were provided in feeders placed in each pasture so cows had ad libitum access. Mineral and MTB-100^{TM} intakes were calculated weekly and estimated per cow per day. Mineral mix composition was adjusted several times in an attempt to get the projected intake at 20 or 40 g MTB-100^{TM}•cow^{-1}•d^{-1}, based on treatment. Final mineral mix composition is shown in Table 3.1. All cows and their calves were individually weighed every 35 d. Cows were assigned a body condition score (BCS) on a scale of 1 to 9 (1 = thin; 9 = obese). Cows and calves were assigned a hair coat (HC) score on a scale of 1 to 10 (1 = short, slick hair; 10 = covered with long hair). Cow rectal temperatures were recorded on the same days. Fecal samples were collected from 3 or 4 pre-designated cows per pasture that were less than 6 years of age and had over 75% Aberdeen Angus breeding. These cows were selected for their predominantly Angus breeding because it was predicted they would be more susceptible to fescue toxicity than those containing higher percentage Beefmaster breeding (Brown et al., 1992; Browning, 2004). Fecal samples were analyzed for EV and LA concentrations (Aiken et al., 2009). Forage grab samples from the pastures were also collected every 35 d and analyzed for DM (AOAC, 1999), CP (AOAC, 1999), NDF (Robertson and Van Soest, 1981), ADF (Goering and Van Soest, 1970), ash (AOAC, 1999) and EV and LA concentrations (Aiken et al., 2009). Forage and fecal samples were analyzed for EV and LA content by the Plant and Soil Science Laboratory at the University of Kentucky. Three metal posts were strategically placed in each pasture. Grab samples were clipped, using trimming shears, every ten steps for two samples in each direction (N, S, E, W) leading away from the post. All samples were freeze dried (-50°C for 7 to 10 d until dry), ground in a Wiley Mill, (1 mm screen) and stored at room temperature in a dry environment until analyzed. Bulls were assigned to each pasture on May 8 and removed on July 10 of each year. Pregnancy was determined via palpation by a veterinarian on September 15 (weaning) each year and conception rates were calculated. At the conclusion of the study, all cows were managed as a herd on KY-31 tall fescue pasture and supplemented with low quality KY-31 tall fescue hay until the following April. Cows continued to be managed in a herd on tall fescue pastures until the next grazing season began the following May. Weather variables (ambient temperature, relative humidity and precipitation) were recorded daily at the Williamstown, KY weather station. These data were downloaded from the University of Kentucky Agricultural Weather Center (http:wwwagwx.ca.uky.edu/).

Study 2: Individually-managed cow/calf pairs

On July 10, at the end of the breeding season, 21 pre-designated cow/calf pairs were removed from the 10.5-ha pastures and randomly allotted to individual, 1.6-ha plots of equivalent pasture (7 plots/supplement, re-randomized each year) without shade. Pre-designated cows met the requirements of 3 to 5 years of age and greater than 75% Angus. Cows continued their respective supplement regimes from this date until calves were weaned on September 15. Data were collected from cow/calf pairs every 35 d, as described in the herd-managed study. Fecal samples were taken from all individual cows. Mineral and MTB-100^{TM} intakes were determined weekly. Forage grab samples were clipped at 30-step intervals in a crisscross walking pattern from one end of each plot to the other. All samples were analyzed using methods previously described.

Statistical Analysis

For herd-managed and individually-managed studies, cow weight, BCS, HC and rectal temperature data were analyzed as a completely randomized design by collection date using PROC GLM of SAS (SAS Institute, 2003). Differences among effects at each collection date were of intrinsic interest. Means were separated using all possible t-tests. The statistical model included fixed effects of year, treatment, cow genetic type and cow age. Time of day was included as a covariate for rectal temperature. Treatments were gradient in nature and consisted of three levels of supplement (0, 20 or 40 g of MTB-100^{TM}) provided in a mineral mix ad libitum. Pasture was the experimental unit and the cow/calf pairs were sample units in Study 1 with three replications per treatment per year. Cow/calf pairs were experimental and sample units in Study 2 with seven replications per treatment per year. Pregnancy data were analyzed using Chi-Square analyses.

Calf data were analyzed similarly with the statistical model including fixed effects of year, treatment, calf genetic type and sex. Birth date and cow age were included as covariates. Forage, fecal and mineral data were analyzed by collection date using PROC

GLM with the statistical model including fixed effects of year and treatment. All data reported are least squares means. Statistical significance indicated at $P < 0.05$ and 0.01.

Results and Discussion

Study 1: Cow/calf performance

Percent Angus (Beefmaster) breeding and age of cows in herd-managed pastures supplemented with MTB-100™ are shown in Table 3.2. Cow weights (Table 3.3) were similar across treatments initially (May 8), at the end of the breeding season (July 10), and at the conclusion of the grazing season (September 15). All cows lost weight during P1 (May 8 to July 10), but compensated for this loss in P2 (July 10 to September 15). Although there were no differences among treatments for either period, weight loss across treatments during breeding, followed by a post-breeding recovery, is a common occurrence for cows grazing endophyte-infected tall fescue pastures from May to September. Ely et al. (2006) found cows, across treatments, lost 6 kg from May to July but gained 20 kg from July to October when fed gradient levels (0, 10, 20 or 40 g) of FEB-200™ during a 3-yr study. The BCS response for P1 followed the weight changes in that cows in each treatment lost body condition. No change in BCS was found for P2. HC scores tended to be lowest for the negative control (0 g MTB-100™) in July and September; however, level of MTB-100™ supplementation did not affect HC changes from May to July or from July to September. The subjectivity of HC scores promotes high variability leading to the challenge of finding statistical significance from minute differences. Rectal temperatures tended to be highest on May 8 then decreased to July 10. September 15 temperatures were similar to July 10 recordings. No supplement treatment effects were found for actual rectal temperatures on any measurement date or for changes in either Period 1 or 2. Weight loss and decreased BCS, HC and rectal temperatures, across treatment, during May and June (breeding season) agree with previous work of Ely et al. (2006). Recovered weight loss, along with minimal changes in BCS, HC and rectal temperatures across treatment in P2, is also consistent with the results reported by Ely et al. (2006) when lactating beef cows grazed endophyte-infected KY-31 tall fescue from May to September. Pregnancy rates were 90.8%, 90.9% and 85.1% for Treatments 0, 20 and 40, respectively (NS).

Calf weights were adjusted for cow age and calf birth date. Herd-managed calf weights and gains (Table 3.4) were similar across treatments. Calf HC scores (Table 3.4) were similar across treatments in May and September, however, 40 g MTB-100^{TM} calves had higher scores (covered with more hair) ($P < 0.05$) than unsupplemented calves in July. Although HC decreased numerically from May to July, treatment differences were statistically nonsignificant. Change was greater ($P < 0.05$) in the negative control than the 40 g treatment in P2.

Despite there being no significant differences for cow performance among treatments, there were differences due to year ($P < 0.01$), genetic type ($P < 0.05$) and cow age ($P < 0.01$). From May to July, cow weight changes, regardless of treatment, were different among years ($P < 0.01$). Cows in 2007 gained weight from May to July while those in 2006 and 2008 lost. The opposite occurred from July to September and 2007 cows lost weight while those in 2006 and 2008 gained. All cows lost body condition from May to July. However, the loss was greater ($P < 0.01$) for cows in 2006 and 2008 than 2007. Cows lost body condition from July to September in 2007 as cows in 2006 and 2008 gained ($P < 0.01$). Hair coat scores of cows did not differ among years. Rectal temperature changes were larger ($P < 0.01$) from May to July for cows in 2007 than for those in 2006 and 2008. Rectal temperatures increased ($P < 0.01$) from July to September in 2006, but decreased in 2007 and 2008. Year differences suggest there may be another uncontrolled factor, other than endophyte, that affects performance when cows graze KY-31 tall fescue. The environment, specifically differences in weather patterns from one year to the next, may have played a role in how cows and their calves responded to the consumption of endophyte-infected tall fescue. Weather variations and impacts on cow performance will be addressed later in this chapter.

Similar to cows, year differences were found for calf weight gains ($P < 0.01$) and HC changes ($P < 0.05$). From May to July, calves gained less ($P < 0.01$) in 2006 versus 2007 and 2008. Calves gained more ($P < 0.05$) from July to September in 2007 compared with 2006 and 2008. Calf HC changes from May to July were not different across years. Changes from July to September were smaller for 2008 compared with 2006 ($P = 0.06$) and 2007 ($P < 0.05$). The differences in calf performance each year may reflect differences found in cow performance. For example, cows in 2006 lost the most weight and body condition from May to July and their calves gained the least when compared with other years. Rutledge et al. (1971) estimated 60% of the variation in calf weaning weight is tied to milk production of beef cows. A decrease in cow body weight and BCS indicates nutrient supply may have been limited, in turn affecting milk production and subsequent calf growth.

Genetic type of cows was grouped by the percent Angus breeding: 1 = ≥ 75% Angus, ≤ 25% Beefmaster; 2 = 50% Angus, 50% Beefmaster; 3 = 51 to 75% Angus, 25 to 49% Beefmaster and 4 = < 50% Angus > 50% Beefmaster. There were no breed x treatment interactions. Cows with less than 50% Angus (genetic type 4) maintained their weight (Table 3.5) in P1 as other genetic types lost weight ($P < 0.05$). These cows also gained more weight ($P < 0.05$) in P2 than other groups. Cows in all breed groups lost body condition from May to July. Cows with greater than 50% Beefmaster (genetic type 4) gained body condition while all other groups lost condition ($P < 0.05$) in P2 (July 10 to September 15). HC of less than 50% Angus decreased more ($P < 0.01$) than the other three genetic types in P1. However, changes from July 10 to September 15 were minimal for all genetic types. Rectal temperature varied across genetic types on May 8, July 10 and September 15, but less than 50% Angus cows had consistently lower ($P < 0.01$) temperatures than those with 51 to 75% Angus (type 3) or those with greater than 75% Angus (type 1). However, rectal temperatures of 51 to 75% Angus cows decreased more ($P < 0.05$) during P1 than all other genetic type groups. No differences were found for rectal temperature changes from July to September. Overall, differences in gain, BCS, HC score and rectal temperature for genetic type support ideas of McMurphy (1990), Brown et al. (1992) and Browning (2004) that high percentage *Bos indicus* breeding is more tolerant than *Bos taurus* to the effects of endophyte-infected tall fescue consumption. Furthermore, results of the current study show effects of endophyte on cow performance (weight loss, BCS loss, higher temperature) tends to be more demonstrative from May to July than from July to September.

Turner (1962) found clipping rough hair coats in both European and tropical breeds of cattle increased body heat loss and body weight gains. Turner (1962) reported the heritability of coat type is 0.63 and the genetic correlation between coat type and weight gain is high. Therefore, the dam or sire can contribute to quality and quantity of the calf's hair coat. Calves averaged ~ 79% Angus 21% Beefmaster across treatments (Table 3.2). There were no genetic type x treatment interactions found for any calf variables. However, calves with greater than 75% Angus weighed and gained less ($P < 0.05$) throughout the study than calves with 51 to 75% Angus (Table 3.6). Calves with ≥ 75% Angus (type 1) had higher HC scores ($P < 0.05$) on May, July and September weigh dates than < 50% Angus calves (type 4). Hair coat changes were not different across genetic type in either P1 or P2. These data appear to differ from the cow data, which found cows with greater than 50% Angus genetics maintained their weight, improved BCS, decreased HC and had lower rectal temperatures than the other three genetic types. However, cows with greater than 50% Beefmaster genetics (genetic type 4) that were bred to Angus bulls would have 51 to 75% Angus (genetic type 3) calves. These calves weighed more and gained more than calves with greater than 75% Angus breeding. These results show genetic type of the dam plays a role in performance of calves, and in this case, cows with > 50% Beefmaster were able to withstand heat stress, indicated by the shedding of hair coat and low rectal temperatures, to produce heavier calves at weaning.

Age of the cows in the herd-managed pastures ranged from 2 to 14 years of age within a given year. Therefore, cows were grouped by age for statistical analysis: 1 = 2-yr-old heifers (first calf); 2 = 3-yr-old cows; 3 = 4-, 5-, 6-yr-olds; and 4 = 7+-yr of age (Table 3.7). There were no interactions for age x treatment. Cows 7-yr and older weighed more ($P < 0.01$) and had higher ($P < 0.01$) BCS than all other groups in May, July and September. Four to 6-yr-olds (Group 3) weighed more ($P < 0.01$) and had higher BCS ($P < 0.01$) than 3-yr-olds and first calf heifers. No differences were found for either weight or BCS between 2-yr-olds and 3-yr-olds, except for the May BCS. These results agree with the expected weight and BCS differences between mature and 2-and 3-yr-old cows (Renquist et al., 2006). These researchers conducted a 5 year experiment with 454 multiparous cows to determine age association with BCS. They reported cow BW and BCS are numerically highest in 7- and 8-yr old cows and numerically lowest in 3-yr-olds at calving, breeding and weaning. However, in the current study, 3-yr-olds gained weight during P1 (breeding) as other age groups lost weight ($P < 0.05$). All groups gained weight in P2 (post-breeding), with 3-yr-olds gaining more ($P < 0.05$) than all other groups. Two-year-olds lost more ($P < 0.05$) BCS than all other groups in both P1 and 2. Under practical production systems, 2-yr-olds typically weigh less than mature cows, but have a weight/BCS relationship that allows adequate productivity during a May to July breeding season. However, as they proceed through the grazing season, they may become “milked down” and lose weight and BCS. Although they may gain some weight and BCS after weaning and until the next calving as 3-yr-olds, weights may be similar to 2-yr-olds (first calf heifers) in May, July and September and BCS may be less than all other age groups (Table 3.7). Consequently, they gain more than other age groups and are able to maintain a more consistent BCS during P1 and 2 (Table 3.7). Osoro and Wright (1992) reported body condition at the start of breeding season has a significant ($P < 0.05$) effect on reproductive performance. Sixty-eight percent of the variation in BCS at the start of the breeding season was accounted for by BCS at calving. Cows with higher BCS lost more weight ($P < 0.05$) from calving to the start of breeding season, but had significantly lower ($P < 0.01$) weight gains during breeding than those with lower BCS. As expected, calves nursing cows in better body condition tended to gain more weight than those suckling lower condition cows (Osoro and Wright, 1992). In turn, data from the current project indicate cows who are able to maintain a weight/BCS relationship that will allow them to conceive as 3-yr-olds were likely to stay in the herd to become cows in Group 3 (4-, 5-, 6-yr-olds) and 4 (7+-yr-olds).

Pastures grazed by the cows in the current study have been infected with endophyte for at least 50 years. Cows have been selected to remain in the herd based on productivity. At weaning, if cows were not pregnant (as determined by a veterinarian), weaned light weight calves, were lame or had an undesirable disposition, they were culled from the herd. These selection criteria have allowed the most productive cows to remain and, concurrently, these cows have generally been those most tolerant of endophyte-infected KY-31 tall fescue.

Rough (heavy) hair coats are a typical symptom of fescue toxicity in cattle during the summer months and it is assumed this is due to inability of the animal to shed its winter hair coat (Aiken et al. 2011). From a literature review, Porter and Thompson (1992) surmised cattle may be unable to shed their winter hair coats due to a hormonal imbalance between prolactin and melatonin. Decreased serum prolactin has shown to cause winter hair growth while an increase should trigger shedding (Porter and Thompson, 1992). Retained winter hair coats can increase susceptibility of cattle to heat stress by insulating the body instead of allowing dissipation of body heat (McClanahan et al., 2008). These workers clipped the rough hair coat of steers and found rectal temperatures were lower than unclipped steers when daily ambient temperature was above 25°C. In the current study, 2-yr-old heifers had higher HC scores and rectal temperatures than other age groups ($P < 0.01$) on the July and September weigh dates (Table 3.7). Cows in their most productive years (4-, 5- and 6-yr-olds) had the smallest decrease in HC score in P1 ($P < 0.05$). However in P2, age groups 3 (4-, 5-, 6-yr-olds) and 4 (7+-yr-olds) had a larger increase in HC score than 2-yr-olds ($P < 0.05$).

The oldest cows (7+) had lower ($P < 0.01$) rectal temperatures (Table 3.7) than Groups 1 and 2 in May, all groups in July ($P < 0.01$) and groups 1 and 3 in September ($P < 0.01$). Two-year-old heifers had the highest rectal temperatures throughout the study ($P < 0.01$) and the largest numerical decrease from May to July. However, the decrease was significant only when compared with 4-, 5-, 6-yr-old cows ($P < 0.01$). These results support the ideas of Spiers et al. (2005) who reported animal age is a major determinant of the critical limits of the thermoneutral zone. Older cows (7+-yr-olds) may be less susceptible to fescue induced heat stress if the upper critical limit of their thermoneutral zone is higher than younger cows. This principle is illustrated in the data of the current study that shows older cows have lower HC scores and rectal temperatures and lose less body condition than 2-yr-olds through a May to September grazing season. Data also support conclusions by McClanahan et al. (2008) and Turner (1961) that thicker hair coats increase susceptibility to heat stress whereas removal of hair reduces rectal temperatures and increases performance of cattle.

Proximate and EV/LA analysis of forage and feces

Forage samples were taken from each pasture for proximate, EV and LA analysis to determine if chemical composition was similar across treatments and therefore all cows consumed comparable amount of nutrients at each collection date. Chemical composition of forage samples collected from herd-managed pastures is presented on a 100% DM basis in Table 3.8. Ash content of 0, 20 and 40 g MTB-100^{TM} supplemented pastures did not differ at any collection during the study. Pastures had similar CP content across treatments on each collection date except in July when unsupplemented (Treatment 0) had a higher ($P < 0.05$) protein content than pastures in the 20 g MTB-100™ treatment. Forage NDF and ADF (Table 3.8) were similar across treatments with the exception of June when the negative control and 40 g MTB-100™ treatment pastures had higher concentrations of each than 20 g MTB-100™ pastures ($P < 0.05$). In general, Ash stayed relatively consistent over the grazing season while CP was highest in May, declined in June and July, and then increased in August and September. Herd-managed pasture NDF and ADF were lowest in May, gradually increased in June, peaked in July and declined in August and September. Typically, the pastures were bush-hogged near the end of July, which may account for the increase in CP and decrease in NDF and ADF observed afterwards in August and September. KY-31 tall fescue produces more than two-thirds of its annual production by late June (Roberts et al., 2009). By July, the forage is predominately stem which is high in NDF and ADF and low in CP. The pastures are then bush-hogged to remove the stems and allow regrowth of the leafy material that is higher in CP. Differences found in forage chemical composition appear to be related to the time when the pastures were bush-hogged in relation to when pasture samples were taken.

Figure 3.2 shows EV concentration (ppm) was highest in June, declined dramatically in July and increased in August and September. The only treatment difference was found in July when pastures supplemented with 40 g MTB-100™ had higher concentration than the 20 g treatment ($P = 0.08$). Lysergic acid concentrations (ppm) were similar across treatments for herd-managed pastures and peaked in June and August of the grazing season (Fig. 3.3). These data are in contrast to Bush and Fannin

(2009) who found EV concentration in tall fescue in Kentucky peaked in May and declined in June and July. However, Fig. 3.2 shows EV increases in August and September which do agree with Bush and Fannin (2009). Agee and Hill (1994) determined EV concentration in the forage in June is 30 to 50% of that in May. The first forage samples in the current experiment were conducted on May 8 whereas the collection dates enumerated by Bush and Fannin (2009) and Agee and Hill (1994) were mid-May. The earlier collection data of the current study may account for some of the contrast because forage production and EV contamination in the forage still had potential to increase from May 8.

If MTB-100^{TM} binds ergot alkaloids in the rumen and prevents absorption, it might be expected cows consuming 20 or 40 g MTB-100^{TM}•cow^{-1}•d^{-1} supplement should have higher concentrations of EV and LA in fecal excretions than those consuming no MTB-100^{TM}. Ely et al. (2006) found cows consuming 10 g of MTB-100^{TM}•cow^{-1}•d^{-1} did not perform as well as those consuming 20 or 40 g. One goal of the current experiment was to determine if 20 g could produce similar results to 40 g, which would be of less cost to producers. Fecal EV concentrations (ppm) for cows in all treatments (Fig. 3.4) peaked in June, corresponding to the high EV content in the forage collected on the same date (Fig. 3.2), declined to July and remained fairly constant in August and September. However, treatment differences were found in July, August and September. In July, cows consuming a projected level of 40 g of MTB-100^{TM}•cow^{-1}•d^{-1} had higher fecal EV concentrations ($P < 0.05$) than those consuming a projected level of 20 g of MTB-100^{TM}. However, cows in the negative control (0 g MTB-100^{TM}) had higher levels of fecal EV than supplement Treatments 20 ($P < 0.05$) and 40 g ($P < 0.01$) in August. Similarly, control cows excreted feces containing higher EV levels ($P = 0.01$) than cows in the 20 g treatment in September. Figure 3.5 shows fecal LA concentrations followed a similar pattern as EV, peaking in June, declining in July and leveling off in August and September. There were no treatment differences for fecal LA during the study. These results show MTB-100^{TM} did not consistently increase fecal excretion of EV and LA in supplemented cows compared with the control and corresponds with the lack of treatment differences found in cow and calf performance data.

Study 2: Cow/calf performance

Genetic type and age of cows managed in individual plots from July 10 to September 15 are listed in Table 3.9. Cow age was similar across treatments, but percent Angus breeding was slightly higher in the negative control than Treatments 20 and 40. Performance of cows, pre-designated to be managed in individual pastures after July 10, is presented in Table 3.10. These cows and their calves were members of herd-managed cow/calf pairs in their respective treatments from May 8 to July 10 (breeding season). Each pair was managed in individual, 1.6-ha KY-31 tall fescue plots from July 10 to September 15. Pre-designated individual cows in the negative control and 20 g MTB-100^{TM} treatment weighed more ($P < 0.05$) and had higher BCS ($P < 0.05$) than those in the 40 g MTB-100^{TM} treatment on May 8 and July 10. These differences ($P < 0.05$) were also existent after the individual management phase from July 10 to September 15. The weight loss of cows in all treatments during P1 was followed by gain in P2, but treatment differences were not significant. Loss of BCS in all treatments from May 8 to July 10 was not significant. Although a difference ($P < 0.05$) was found for BCS change in P2, numerical changes were minimal. These results are similar to those for the herd-managed cows (Table 3.3). Hair coat scores (Table 3.10) tended to be higher for Treatment 40 cows in May and July, but no differences were found in September. There were no differences for HC change during P1. The HC score change was smaller ($P < 0.05$) 40 g MTB-100^{TM} cows than for those in the 20 g MTB-100^{TM} treatment from July to September (P2). Rectal temperatures and changes were not affected by treatment. Pregnancy rates of individually-managed cows for Treatments 0, 20 and 40 g MTB-100^{TM} were 81%, 95% and 91% respectively (NS). However, these rates are not a reflection on individual management because all were herd-managed during the breeding season from May 8 to July 10.

Genetic type of calves in each supplement treatments is presented in Table 3.9. Calf weights in Table 3.11 were adjusted for cow age and calf birth date. Calf weights and HC scores (Table 3.11) were similar across treatments for each weigh date, as were period changes.

Year differences ($P < 0.01$) were found for weight, BCS, HC and rectal temperature changes of individually-managed cow data. These trends that occurred across years were similar to those in herd-managed pastures. Pre-designated individual cows, when herd-managed from May to July, gained more weight ($P < 0.01$), lost less BCS ($P < 0.05$) and had a larger decrease in HC score ($P < 0.10$) and rectal temperature ($P < 0.01$) in 2007 than in 2006 and 2008. When individually-managed from July to September, cows in 2007 lost more weight ($P < 0.01$) and BCS ($P < 0.01$) compared to those in 2006 and 2008. Cows in 2007 had a larger ($P < 0.01$) increase in HC score and a smaller decrease in rectal temperature ($P < 0.01$) than 2008. Hair coat and rectal temperature changes, from July to September, were not different between 2006 and 2007.

Year differences ($P < 0.05$) were also found for calf weight gains and HC changes. Gains differed among years from May to July ($P < 0.05$), but no differences were found from July to September. Calves in 2007 gained more weight while managed in the herd from May to July than those in 2006 and 2008. This reflects the same changes found for herd-managed calves across years. On the other hand, hair coat scores of pre-designated individual calves did not reflect those of herd-managed. From May to July, the 2006 calves had a greater decrease ($P < 0.01$) in HC score than either 2007 or 2008. However, while individually-managed from July to September, those in 2006 had the largest increase ($P < 0.01$) in HC score compared with 2007 and 2008. The larger decrease in HC score in 2006 occurred with calves that had the smallest weight gain. During the same time period, calves in 2007 gained the most, while HC change was minimal. These results contrast the ideas of Turner (1962) who reported body weight gains of calves were increased when rough hair coats were removed. However, the physical state of the cow also influences the performance of the calf.

These spring-born calves are dependent upon the dam’s milk to meet their nutritional needs especially during early lactation which, in this case, coincides with the beginning of the grazing season. It is important during this time for the dam to be able to support calf nutritional demands by providing enough milk for growth. Therefore it is ideal for cows to weigh more during this time because they tend to undergo a negative energy balance while trying to meet the demands of lactation, causing them to lose weight. In this study, 2007 calves nursing pre-designated individuals weighed heavier in July and at weaning (September) when nursing cows that gained weight from May to July versus those nursing cows that lost during the same period in 2006 and 2008. Despite

2007 cows losing weight from July to September, overall calf weaning weights were greater in 2007 than 2006 and 2008. These results indicate calf gain is most affected by the status of the cow early in the grazing season. This supports the ideas of Rutledge et al. (1971) who found 60% of the variance in calf weaning weight was tied to cow milk production. These results also suggest condition of the dam may have a greater influence on calf performance than the loss of hair coat.

Pre-designated individual cows were chosen by age (less than 6 years of age) for their susceptibility to heat stress induced by endophyte-infected tall fescue. They were also chosen for genetic type (greater than 75% Angus) because the *Bos taurus* breeds are less heat tolerant than *Bos indicus* (Brown et al., 1992; Browning, 2004). Theoretically, if there was a potential for fescue toxicosis to occur, cows of these ages and genetic types should have been most susceptible. No differences were observed for genetic type. However, age differences ($P < 0.05$) were found (Table 3.12), regardless of supplement treatment. Four to 6-yr-olds (Group 3) weighed more ($P < 0.01$) and had higher BCS ($P < 0.01$) than 3-yr-olds (Group 2) on May 8, July 10 and September 15 weigh dates. However, weight changes of the two individual cow age groups during P1 and 2 did not differ. From May 8 to July 10 (P1), 3-yr-old cows lost more body condition ($P = 0.04$) than more mature cows. Three-yr-olds also had higher hair coat scores than 4-, 5-, 6-yr-olds ($P < 0.01$) on the initial weigh date (May 8) when assigned to their respective herd-managed pastures, but no other differences were found when assigned to individual plots on July 10 or at the conclusion of the grazing period September 15. HC changes did not differ between the two age groups for P1 and 2, but changes were similar to age groups 2 and 3 managed in a herd for the duration of the study (Table 3.7). Four to 6-yr-old cows tended to have lower rectal temperatures than 3-yr-olds on May 8 ($P = 0.09$), July 10 ($P = 0.10$) and September 15 ($P = 0.05$). However, the rectal temperature change was not statistically significant for either P1 or 2. These results are consistent with differences found in herd-managed cows (Table 3.7). Three-yr-old pre-designated individual cows weighed less ($P < 0.01$), had lower BCS ($P < 0.01$) and numerically higher HC scores and rectal temperatures than 4-, 5- and 6-yr-olds throughout the study resembling those in the herd-managed pastures.

Proximate and EV/LA analysis of forage and feces

Forage samples were taken from plots on each collection date to determine if chemical composition was similar across treatments. Individual plot forage ash, CP, NDF and ADF (DM basis) concentrations were similar across treatments on July 10, August 13 and September 15 collections (Table 3.13). Numerically, percent ash remained constant, CP steadily increased, and NDF and ADF decreased slightly from July 10 to September 15. Although absolute values of herd and individually-managed pasture forage (Table 3.8 versus 3.13) were numerically different, changes from July to September were similar.

There were no treatment differences for individual plot forage EV and LA (Fig. 3.6 and 3.7). The EV concentration did not begin to increase in the individual plots until August, unlike in herd-managed pastures in which the second increase in EV production started in July (Fig. 3.2). Lysergic acid concentration of individual plot forage remained relatively constant from May to September, ranging from 0.23 to 0.33 ppm. Forage LA from herd-managed was more erratic during July, August and September (Fig. 3.3) when the concentration ranged from 0.13 to 0.27 ppm. Still, forage from pastures where cows were supplemented with 0, 20 or 40 g MTB-100^{TM}•cow^{-1}•d^{-1} had similar LA levels on each collection date.

Fecal EV (Fig. 3.8) was higher for Treatments 0 ($P < 0.01$) and 40 ($P < 0.05$) compared with Treatment 20 on the July collection date when cows were removed from their herd-managed pastures and assigned to their respective plots. Fecal LA concentrations (Fig. 3.9) did not differ among treatments at any point during the grazing period for individually-managed cows. It is important to note the EV and LA in the feces follow a similar pattern to the EV and LA concentrations in the forage while in herd-managed pastures and when they were moved to individual plots. When managed in individual plots, cow fecal EV and LA gradually increased from July to September.

Mineral consumption

Target mineral consumption was 85.2 to 113.6 g•cow^{-1}•d^{-1} of the total mineral mix (Table 3.1). Based on targeted total mineral mix consumption, MTB-100^{TM} was mixed so it would be consumed at rates of 20 and 40 g of MTB-100^{TM}•cow^{-1}•d^{-1}. Herd-managed cows in Treatments 0, 20 and 40 consumed more than projected intake of mineral mix (136, 162 and 206 g; Fig. 3.10) and MTB-100^{TM} (0, 25 and 56 g; Fig. 3.11) from May to July. However, from July to September, supplemented cows consumed less than 20 or 40 g MTB-100^{TM}•cow^{-1}•d^{-1} (16 and 36 g; Fig. 3.11). In contrast, cows in individually-managed plots consumed more than targeted amount of mineral (145, 199 and 229 g; Fig. 3.12) and MTB-100^{TM} (0, 31 and 62 g; Fig. 3.13) from July to September for Treatments 0, 20 and 40, respectively. Note daily mineral consumption from May to July by herd (Fig. 3.10) and individually (Fig. 3.12) managed cows was the same because all cows were herd-managed during this period.

Since the mineral mix was provided ad libitum, when, how often or which cows in the herd-managed pastures actually consumed MTB-100^{TM} could not be determined. Conversely, in individually-managed pastures, consumption patterns could be established. Some cows would go several days without consuming any mineral mix, but would consume excessive amounts during the following few days. Evans and Dawson (2007) demonstrated maximum binding of ergotamine by the yeast cell wall product, Mycosorb, occurred 1.5 h after incubation. Because mineral consumption was not regulated, the time relationship between MTB-100^{TM} consumption in relation to grazing was not established. Therefore, the inconsistency of mineral mix intake by cows could explain why no differences were found for treatment effects on cow performance and fecal ergot alkaloid concentrations taken on specific dates during the grazing season. Ely et al. (2006) used corn as a vehicle for providing MTB-100^{TM}, which was fed at the same time each day (0700 h), and found MTB-100^{TM} supplementation improved cow/calf performance when grazing the same endophyte-infected pastures used in the current study. This improved performance was attributed to consumption of MTB-100^{TM} near the time of forage consumption so maximum adsorption of toxins present in endophyte-infected KY-31 tall fescue could occur. However, the cost of supplemental corn, as a carrier of MTB-100^{TM}, and the ration required for daily feeding of mature beef cows makes this system impractical. Theoretically, an efficient method of supplementing MTB-100^{TM} can be through a complete mineral mix in which animals have ad libitum access. Still, daily mineral intake must be controlled to an established projected level if benefits of MTB-100^{TM} are to be realized. It may be more effective to include multiple mineral feeders placed strategically in herd-managed pastures such as in the area that provides the most shade, near the water source and at the pasture entrance. This would allow easier access to the mineral and MTB-100^{TM}, especially if high ambient temperature plays a role in animal behavior.

Weather

Statistical analysis of cow performance, forage composition and fecal EV and LA concentrations showed there were differences due to year. Environmental effects should be taken into consideration when evaluating why these differences occurred. Weather data were downloaded from the closest weather station to the research farm. The average maximum temperature (°C), total precipitation (cm), and maximum relative humidity (%) for each month of the grazing period are shown in Table 3.14. The average maximum ambient temperature during the 2007 grazing season was higher ($P < 0.05$) than 2006 except for July. Ambient temperature was similar in 2006 and 2008 except in September ($P < 0.05$). Temperatures in May and August, 2007 were higher than 2008 ($P < 0.05$).

Total rainfall (Table 3.14) from May 1 to October 1 in 2006, 2007 and 2008 was 64.76, 36.57 and 53.41 cm, respectively. Monthly rainfall was most consistent in 2006, except for the excessive amount in September (21.95 cm = 34% of total). The least amount of rain fell in 2007, especially in May. In contrast, excessive amounts fell in May and June, 2008.

Relative humidity (Table 3.14) was higher ($P < 0.05$) every month of 2006 than 2007. The humidity of 2006 coincides with the high rainfall (64.76 cm) and relatively lower ambient temperatures. The year of 2007 had the lowest rainfall (36.57 cm) and lower ($P < 0.05$) relative humidity readings every month than 2006 (the year with the highest rainfall). Maximum relative humidity in May and June, 2008 was higher (P <

0.05) than 2007, but lower in August. The humidity in June, July, August and September, 2008 was lower ($P < 0.05$) than in 2006.

The variability in the environment (temperature, rainfall, and relative humidity) affects quality and quantity of forage available for consumption by ruminants. According to the literature (Roberts et al., 2009), forage DM production is influenced by rainfall and environmental temperature. As fescue DM increases, EV tends to increase as well, even though production of ergot alkaloids by the fungus is independent of forage DM production (Bush and Fannin, 2009). Therefore, environmental factors affecting DM production can also have an effect on EV and LA production by the fungus. Figure 3.14 shows the total monthly rainfall of the grazing period versus the average concentration of EV in the forage across the three years. The relationship appears close, except in July. At this time, ambient temperature becomes a factor and DM production decreases. Since symptoms of fescue toxicity are associated with high ambient temperatures (above 31°C, Hemken et al., 1981), cow weight changes could have been influenced by differences in the environment over the years. Figure 3.15 compares average cow weight, across treatments, with average EV concentration found across all pastures for all three years. The average ambient temperature during this study was highest during July and August which corresponded with the greatest decrease in cow weight (Fig. 3.15) as well as decreased mineral mix intake by herd-managed cows (Fig. 3.10). This supports the findings of Hemken et al. (1981) who reported cattle performance is greatly hindered when consuming E+ tall fescue under heat stress conditions. Cow weight continued to decrease until the EV concentrations had fallen during July and August. The cows then gained weight back after forage EV had decreased to its lowest concentration of the season and as forage production increased in the late summer/early fall. These two graphs demonstrate how rainfall is related to forage EV concentration and how EV is related to cow weight changes, perhaps providing some insight into the time during the grazing season that is most responsive to finding ways to alleviate fescue toxicity symptoms and improve cow performance.

Implications

No measureable benefits of MTB-100™ supplementation were found towards direct increases in performance of beef cows and their calves. However previous research has shown closer regulation of daily intake of MTB-100™ has the potential to produce heavier cow weights, maintain higher body conditions and decrease rectal temperatures. Therefore, in an improved regulated regime, MTB-100™ may be used as a safety factor, especially when environmental conditions vary from year to year. The cows that may benefit the most from MTB-100™ supplementation are those more susceptible to fescue toxicity, such as more immature cows (2 to 3 year olds) and those that, genetically, exhibit less heat tolerance.

Table 3.1. Final ingredient composition (percent) of mineral mix projected to provide 0, 20 or 40 g MTB-100™•cow^{-1}•d^{-1}.

	Treatment[a]		
Ingredient	0	20	40
Southern States mineral 2:1	98.0	43.5	38.4
Corn oil	2.0	1.2	1.3
MTB-100™	--	15.3	27.0
Salt	--	40.0	33.3

[a] MTB-100™ (g•cow^{-1}•d^{-1}).

Table 3.2. Initial data for herd-managed cows and calves grazing KY-31 tall fescue and supplemented with different levels of MTB-100™ (3-yr study).

	Treatment[a]		
	0	20	40
Cows			
Number	76	88	94
% Angus	75.6	74.3	74.3
Age, yr	5.4	5.1	5.1
Calves			
Number	76	88	93
% Angus	78.7	79.1	79.9

[a] MTB-100™ ($g \cdot cow^{-1} \cdot d^{-1}$).

Table 3.3. Least squares means for herd-managed cow performance when grazing KY-31 tall fescue and supplemented with different levels of MTB-100™.

	Treatment[a]			
Collection	0	20	40	SEM
Weight, kg/cow				
May 8	518.7	520.6	518.4	6.7
Jul 10	515.2	516.1	512.8	6.8
Sep 15	520.4	522.5	517.4	6.2
P1 change[b]	-3.5	-4.5	-5.6	2.6
P2 change[b]	5.2	6.4	4.6	3.1
BCS[c]				
May 8	5.6	5.6	5.7	0.1
Jul 10	5.3	5.3	5.4	0.1
Sep 15	5.3	5.3	5.4	0.1
P1 change[b]	-0.3	-0.3	-0.3	0.1
P2 change[b]	0.0	0.0	0.0	0.1
HC[d]				
May 8	7.3	7.3	7.4	0.2
Jul 10	5.5[e]	5.7[ef]	6.0[f]	0.2
Sep 15	5.7[e]	6.2[ef]	6.3[f]	0.2
P1 change[b]	-1.8	-1.6	-1.4	0.2
P2 change[b]	0.2	0.5	0.3	0.2
Rectal temperature, °C				
May 8	38.9	39.1	39.1	0.2
Jul 10	38.7	38.8	38.8	0.1
Sep 15	38.7	38.7	38.9	0.2
P1 change[b]	-0.2	-0.3	-0.3	0.2
P2 change[b]	0.0	-0.1	0.1	0.1

[a] MTB-100™ ($g \bullet cow^{-1} \bullet d^{-1}$).

[b] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.4. Least squares means for calf performance when nursing herd-managed cows grazing KY-31 tall fescue and supplemented with different levels of MTB-100™.

	Treatment[a]			
Collection	0	20	40	SEM
Weight, kg/calf				
May 8	112.8	111.9	112.6	1.8
Jul 10	172.3	170.9	171.6	2.5
Sep 15	235.9	233.8	234.4	3.2
P1 gain[b]	59.5	59.0	59.0	1.3
P2 gain[b]	63.5	62.9	62.8	1.5
HC[c]				
May 8	7.6	7.8	7.7	0.2
Jul 10	6.6[d]	7.1[de]	7.3[e]	0.3
Sep 15	7.4	7.8	7.6	0.2
P1 change[b]	-1.0	-0.7	-0.4	0.2
P2 change[b]	0.8[d]	0.7[de]	0.3[e]	0.2

[a] MTB-100™ ($g \cdot cow^{-1} \cdot d^{-1}$).

[b] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[c] 1 = short hair, slick; 10 = covered with long hair.

[d, e] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.5. Least squares means for cow performance by genetic type when grazing KY-31 tall fescue in herd-managed pastures.

	Genetic type[a]				
Collection	1	2	3	4	SEM
Number	121	27	72	38	
Weight, kg/cow					
May 8	522.1	511.1	527.5	516.3	5.8
Jul 10	515.9	504.4	521.6	517.1	6.2
Sep 15	517.7	508.7	525.5	528.4	6.3
P1 change[b]	-6.2[e]	-6.7[e]	-5.9[e]	0.8[f]	2.0
P2 change[b]	1.8[e]	4.3[e]	3.9[e]	11.3[f]	1.9
BCS[c]					
May 8	5.7	5.5	5.8	5.6	0.1
Jul 10	5.4	5.2	5.5	5.3	0.1
Sep 15	5.3	5.1	5.4	5.5	0.1
P1 change[b]	-0.3	-0.3	-0.3	-0.3	0.1
P2 change[b]	-0.1[e]	-0.1[e]	-0.1[e]	0.2[f]	0.1
HC[d]					
May 8	7.4[e]	6.7[f]	8.0[g]	7.3[ef]	0.2
Jul 10	6.1[e]	5.9[e]	6.5[e]	4.4[f]	0.2
Sep 15	6.7[e]	6.4[e]	6.5[e]	4.6[f]	0.2
P1 change[b]	-1.3[e]	-0.8[e]	-1.5[e]	-2.9[f]	0.3
P2 change[b]	0.6[e]	0.5[ef]	0.0[f]	0.2[ef]	0.2
Rectal temperature, °C					
May 8	39.2[e]	38.9[f]	39.2[e]	38.8[f]	0.1
Jul 10	39.0[e]	38.8[ef]	38.7[fg]	38.6[h]	0.1
Sep 15	39.0[f]	38.7[e]	38.7[e]	38.5[g]	0.1
P1 change[b]	-0.2[eh]	-0.1[ef]	-0.5[g]	-0.2[h]	0.1
P2 change[b]	0.0	-0.1	0.0	-0.1	0.1

[a] 1 = ≥ 75% Angus ≤ 25% Beefmaster; 2 = 50% Angus 50% Beefmaster; 3 = 51 to 75% Angus, 49 to 25% Beefmaster; 4 = < 50% Angus > 50% Beefmaster.

[b] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f, g, h] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.6. Least squares means for calf performance by genetic type when nursing cows grazing KY-31 tall fescue in herd-managed pastures.

	Genetic type[a]				
Collection	1	2	3	4	SEM
Number	154	8	56	39	
Weight, kg/calf					
May 8	110.7[d]	107.9[de]	116.0[e]	115.0[de]	2.7
Jul 10	168.9[d]	165.6[de]	178.5[e]	173.5[de]	3.9
Sep 15	228.5[d]	228.6[de]	242.0[e]	238.7[de]	4.9
P1 gain[b]	58.2[d]	57.7[de]	62.5[e]	58.5[de]	1.7
P2 gain[b]	59.6[d]	63.0[de]	63.5[e]	65.2[de]	1.8
HC[c]					
May 8	8.2[d]	7.5[def]	7.8[e]	7.2[f]	0.2
Jul 10	7.6[d]	6.9[def]	7.1[e]	6.4[f]	0.3
Sep 15	8.5[d]	7.1[d]	7.7[e]	7.1[e]	0.3
P1 change[b]	-0.6	-0.6	-0.7	-0.8	0.3
P2 change[b]	0.9	0.2	0.6	0.7	0.2

[a] 1 = ≥ 75% Angus ≤ 25% Beefmaster; 2 = 50% Angus 50% Beefmaster; 3 = 51 to 75% Angus, 49 to 25% Beefmaster; 4 = < 50% Angus > 50% Beefmaster.

[b] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[c] 1 = short hair, slick; 10 = covered with long hair.

[d, e, f] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.7. Least squares means for cow performance by age when grazing KY-31 tall fescue in herd-managed pastures.

	Age[a]				
Collection	1	2	3	4	SEM
Number	78	29	62	89	
Weight, kg/cow					
May 8	471.0[e]	475.6[e]	551.4[f]	579.0[g]	5.5
Jul 10	462.0[e]	478.7[e]	546.8[f]	571.4[g]	5.9
Sep 15	465.2[e]	491.4[f]	550.2[g]	573.5[h]	5.9
P1 change[b]	-9.0[e]	3.1[f]	-4.6[e]	-7.6[e]	1.9
P2 change[b]	3.2[e]	12.7[f]	3.4[e]	2.1[e]	1.8
BCS[c]					
May 8	5.4[e]	4.8[f]	5.9[g]	6.5[h]	0.1
Jul 10	4.9[e]	4.6[e]	5.6[f]	6.3[g]	0.1
Sep 15	4.6[e]	4.7[e]	5.6[f]	6.4[g]	0.1
P1 change[b]	-0.5[e]	-0.2[f]	-0.3[f]	-0.2[f]	0.1
P2 change[b]	-0.3[e]	0.1[f]	0.0[f]	0.1[f]	0.1
HC[d]					
May 8	8.3[e]	7.8[e]	6.4[f]	6.8[f]	0.2
Jul 10	6.9[f]	5.9[e]	5.5[e]	4.7[g]	0.2
Sep 15	6.9[f]	6.0[e]	6.0[e]	5.3[g]	0.2
P1 change[b]	-1.4[eg]	-1.9[g]	-0.9[e]	-2.1[eg]	0.3
P2 change[b]	0.0[e]	0.1[eh]	0.5[fh]	0.6[f]	0.2
Rectal temperature, °C					
May 8	39.5[f]	39.1[g]	38.8[e]	38.8[e]	0.1
Jul 10	39.1[f]	38.8[e]	38.7[e]	38.5[g]	0.1
Sep 15	39.1[e]	38.7[fg]	38.7[f]	38.6[g]	0.1
P1 change[b]	-0.4[e]	-0.3[ef]	-0.1[fg]	-0.3[ef]	0.1
P2 change[b]	0.0[e]	-0.1[eh]	0.0[fh]	0.1[f]	0.1

[a] 1 = 2 yr; 2 = 3 yr; 3 = 4, 5, 6 yr; 4 = 7+ yr.

[b] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f, g, h] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.8. Chemical composition of KY-31 tall fescue forage collected from herd-managed pastures (DM basis).

Collection	Treatment[a] 0	20	40	SEM
Ash				
May 8	10.1	9.8	9.6	0.5
Jun 16	7.8	9.2	7.4	0.3
Jul 10	8.1	7.8	8.0	0.2
Aug 13	9.0	8.7	8.9	0.2
Sep 15	8.8	8.4	8.8	0.2
CP				
May 8	16.8	15.5	16.2	0.5
Jun 16	8.8	8.2	8.7	0.5
Jul 10	8.8[b]	7.5[c]	8.4[bc]	0.4
Aug 13	10.8	10.4	10.9	0.3
Sep 15	12.4	11.1	11.8	0.6
NDF				
May 8	54.0	54.5	54.4	0.8
Jun 16	65.0[b]	63.5[c]	65.2[b]	0.5
Jul 10	67.6	69.9	68.9	0.9
Aug 13	61.7	62.7	61.8	0.9
Sep 15	61.4	62.9	62.6	1.0
ADF				
May 8	27.7	27.7	27.9	0.6
Jun 16	36.7[b]	35.4[c]	37.1[b]	0.4
Jul 10	37.3	38.7	38.2	0.8
Aug 13	35.5	35.5	36.0	0.8
Sep 15	33.9	35.1	35.7	1.1

[a] MTB-100[TM] ($g \cdot cow^{-1} \cdot d^{-1}$).

[b, c] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.9. Initial data of cows and calves managed in individual plots of KY-31 tall fescue from July to September and supplemented with different levels of MTB-100™ (3-yr study).

	Treatment[a]		
	0	20	40
Cows			
Number	21	21	21
% Angus	90.4	81.5	82.6
Age, yr	3.8	3.8	3.8
Calves			
Number	21	21	21
% Angus	87.2	86.0	90.9

[a] MTB-100™ ($g \cdot cow^{-1} \cdot d^{-1}$).

Table 3.10. Least squares means for performance of cows managed in individual plots from July to September and supplemented with different levels of MTB-100™.

	Treatment[a]			
Collection	0	20	40	SEM
Weight, kg/cow				
May 8[b]	553.3[f]	548.6[f]	510.4[g]	12.3
Jul 10	541.6[f]	545.1[f]	505.2[g]	13.0
Sep 15	549.7[f]	551.2[f]	513.2[g]	12.3
P1 change[c]	-11.7	-3.5	-5.1	5.2
P2 change[c]	8.0	6.1	8.0	4.4
BCS[d]				
May 8[b]	6.0[f]	6.2[f]	5.5[g]	0.2
Jul 10	5.8[f]	5.7[f]	5.0[g]	0.2
Sep 15	5.6[fg]	5.7[f]	5.2[g]	0.3
P1 change[c]	-0.2	-0.5	-0.5	0.1
P2 change[c]	-0.2[e]	0.0[fg]	0.2[g]	0.2
HC[e]				
May 8[b]	7.0[f]	7.1[fg]	7.8[g]	0.4
Jul 10	6.6[fg]	6.0[f]	7.0[g]	0.5
Sep 15	7.2	7.3	7.4	0.4
Period 1 change[c]	-0.4	-1.1	-0.8	0.5
Period 2 change[c]	0.6[fg]	1.3[f]	0.4[g]	0.4
Rectal temperature, °C				
May 8[b]	39.0	38.9	38.9	0.3
Jul 10	38.8	38.9	38.9	0.3
Sep 15	38.7	38.6	38.7	0.2
P1 change[c]	-0.2	0.0	0.0	0.3
P2 change[c]	-0.2	-0.3	-0.3	0.3

[a] MTB-100™ ($g \cdot cow^{-1} \cdot d^{-1}$).

[b] Cows and calves were in herd managed pastures from May 8 to Jul 10.

[c] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[d] 1 = emaciated; 9 = obese.

[e] 1 = short hair, slick; 10 = covered with long hair.

[f, g] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3.11. Least squares means for performance of calves nursing cows when managed in individual plots of KY-31 tall fescue from July to September and supplemented with different levels of MTB-100^{TM}.

	Treatment[a]			
Collection	0	20	40	SEM
Weight, kg/calf				
May 8[b]	105.2	107.5	107.7	4.5
Jul 10	156.9	162.0	162.5	6.6
Sep 15	216.2	221.3	221.5	8.2
P1 gain[c]	51.7	54.5	54.8	2.9
P2 gain[c]	59.4	59.3	59.0	2.9
HC[d]				
May 8[b]	7.1	7.1	7.1	0.2
Jul 10	6.6	6.5	6.7	0.4
Sep 15	7.3	7.2	7.4	0.4
P1 change[c]	-0.5	-0.6	-0.4	0.4
P2 change[c]	0.7	0.7	0.7	0.4

[a] MTB-100^{TM} (g•cow^{-1}•d^{-1}).

[b] Cows and calves were in herd managed pastures from May 8 to Jul 10.

[c] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 10.

[d] 1 = short hair, slick; 10 = covered with long hair.

Table 3.12. Least squares means for performance of cows of two age groups and managed in individual plots of KY-31 tall fescue from July to September.

	Age[a]			
Collection	2	3	SEM	P value
Number	27	36		
Weight, kg/cow				
May 8[b]	506.7	568.1	11.3	<0.01
Jul 10	499.5	561.8	12.0	<0.01
Sep 15	505.5	570.5	11.4	<0.01
P1 change[c]	-7.2	-6.3	4.8	0.83
P2 change[c]	6.0	8.7	4.1	0.48
BCS[d]				
May 8[b]	5.5	6.3	0.2	<0.01
Jul 10	5.0	6.0	0.2	<0.01
Sep 15	4.9	6.1	0.2	<0.01
P1 change[c]	-0.5	-0.3	0.1	0.04
P2 change[c]	-0.1	0.1	0.1	0.61
HC[e]				
May 8[b]	7.9	6.7	0.4	<0.01
Jul 10	6.8	6.2	0.4	0.12
Sep 15	7.5	7.1	0.4	0.27
P1 change[c]	-1.1	-0.5	0.4	0.19
P2 change[c]	0.7	0.9	0.4	0.41
Rectal temperature, °C				
May 8[b]	39.1	38.8	0.3	0.09
Jul 10	39.0	38.8	0.3	0.10
Sep 15	38.7	38.6	0.2	0.05
P1 change[c]	-0.1	-0.1	0.2	0.90
P2 change[c]	-0.3	-0.2	0.3	0.74

[a] 2 = 3 yr; 3 = 4, 5, 6 yr.

[b] Cows and calves were in herd managed pastures from May 8 to Jul 10.

[c] Period 1 = May 8 to Jul 10; Period 2 = Jul 10 to Sep 15.

[d] 1 = emaciated; 9 = obese.

[e] 1 = short hair, slick; 10 = covered with long hair.

Table 3.13. Chemical composition of KY-31 tall fescue forage collected from individual plots (DM basis).

	Treatment[a]			
	0	20	40	SEM
Ash				
Jul 10	8.5	8.2	8.2	0.1
Aug 13	8.3	8.3	8.2	0.1
Sep15	8.2	8.5	8.4	0.2
CP				
Jul 10	8.9	8.9	8.8	0.2
Aug 13	10.0	10.3	10.2	0.2
Sep15	11.0	11.7	11.0	0.3
NDF				
Jul 10	66.6	66.3	65.9	0.5
Aug 13	65.6	64.5	65.4	0.5
Sep15	62.5	62.6	62.1	0.7
ADF				
Jul 10	37.1	37.0	36.6	0.5
Aug 13	36.0	34.9	35.7	0.5
Sep15	34.8	34.3	34.2	0.5

[a] MTB-100™ (g•cow^{-1}•d^{-1}).

Table 3.14. Weather data recorded by Williamstown, KY weather station.

Year	May	Jun	Jul	Aug	Sep
	Month				
	Avg. Maximum Ambient Temperature (°C)				
2006	22.1[a]	27.4[a]	30.3[a]	30.3[a]	22.8[a]
2007	26.6[b]	30.0[b]	29.7[a]	34.2[b]	29.5[b]
2008-	21.8[a]	28.9[ab]	29.6[a]	29.8[a]	28.3[b]
	Total Precipitation (cm)				
2006	9.07	12.88	11.18	9.68	21.95
2007	1.93	7.44	12.60	5.38	9.22
2008	17.6	18.29	9.17	5.00	3.35
	Avg. Maximum Relative Humidity (%)				
2006	94.8[a]	97.0[a]	97.2[a]	96.7[a]	95.6[a]
2007	92.0[b]	90.2[b]	90.2[b]	93.6[b]	91.5[b]
2008	95.0[a]	95.0[c]	91.4[b]	91.5[c]	90.1[b]

[a, b, c] Within a column, means without a common superscript differ ($P < 0.05$).

Figure 3.1. Experimental timeline for 2006, 2007, 2008.

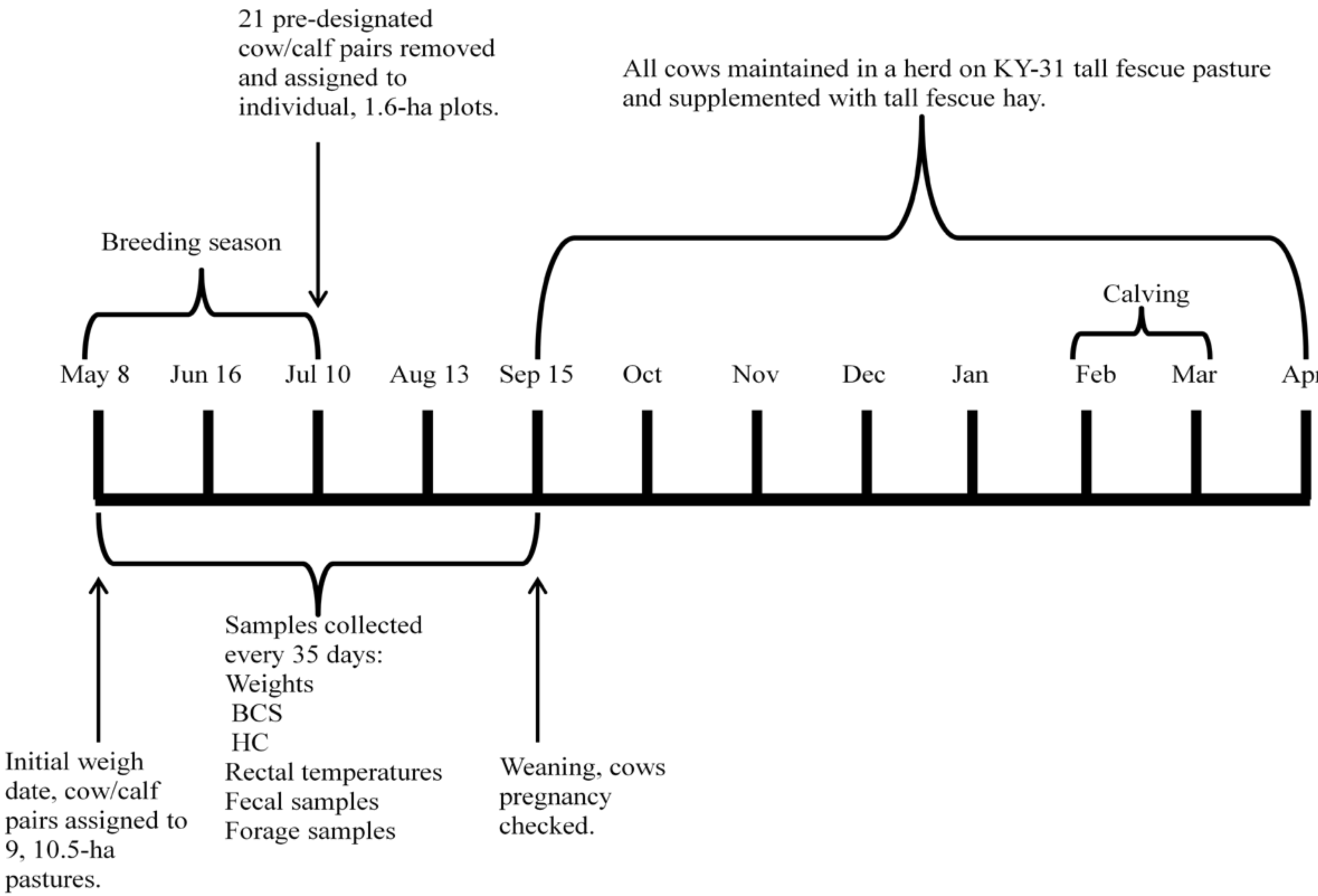


Figure 3.2. Ergovaline content (ppm) of KY-31 tall fescue forage grazed by herd managed cows and calves supplemented with MTB-100™ projected to consume 0, 20 or 40 g•cow^{-1}•d^{-1}.

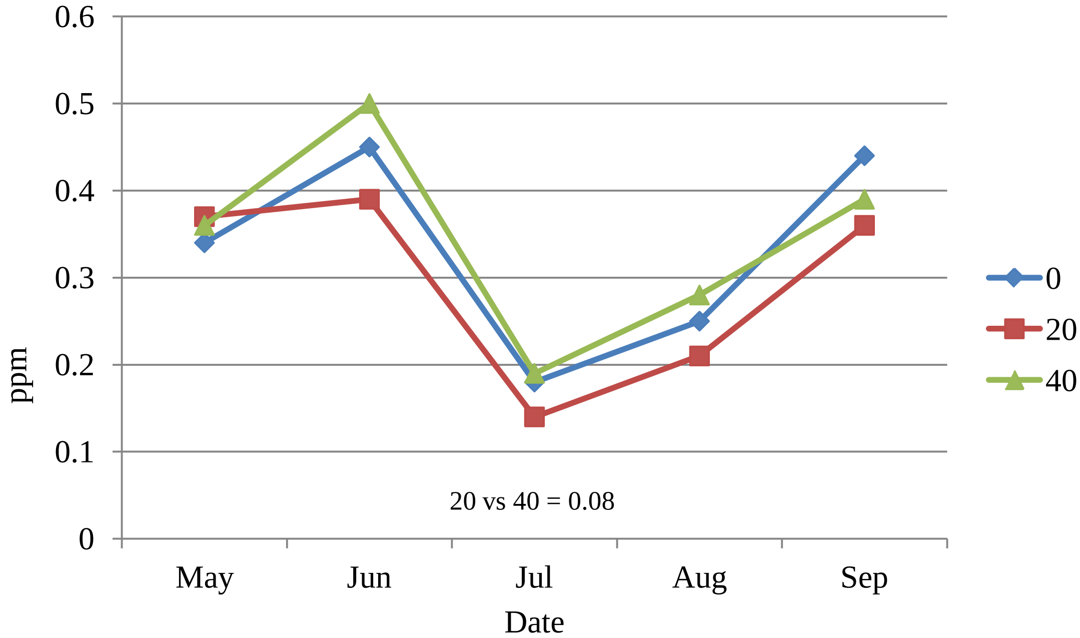


Figure 3.3. Lysergic acid content (ppm) of KY-31 tall fescue forage grazed by herd managed cows and calves supplemented with MTB-100™ projected to consume 0, 20 or 40 g•cow^{-1}•d^{-1}.

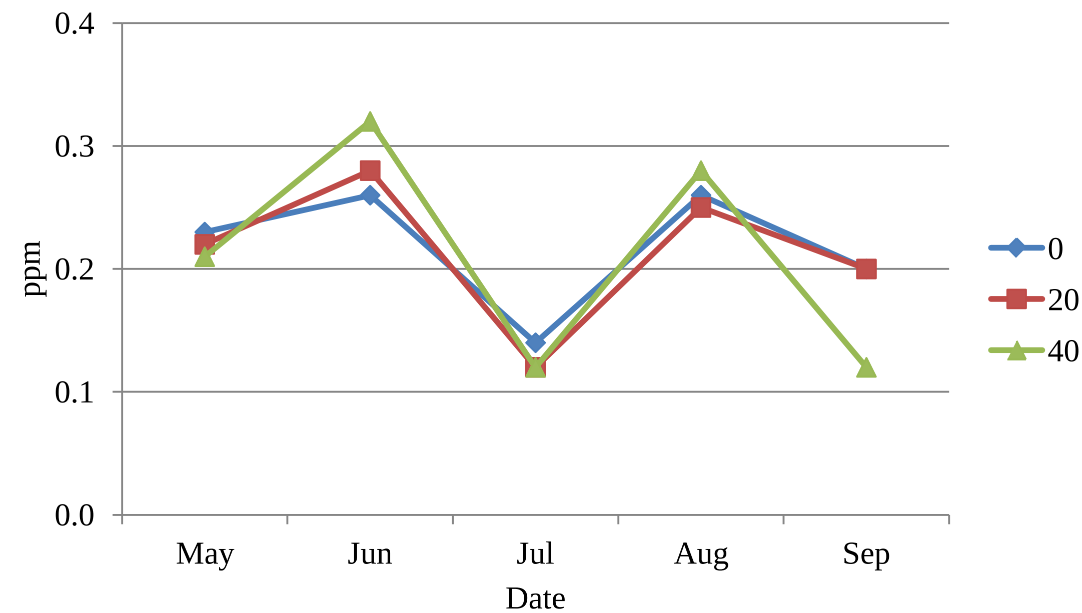


Figure 3.4. Ergovaline content (ppm) of fecal samples collected from herd managed cows grazing KY-31 tall fescue and supplemented with MTB-100™ at projected consumption rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

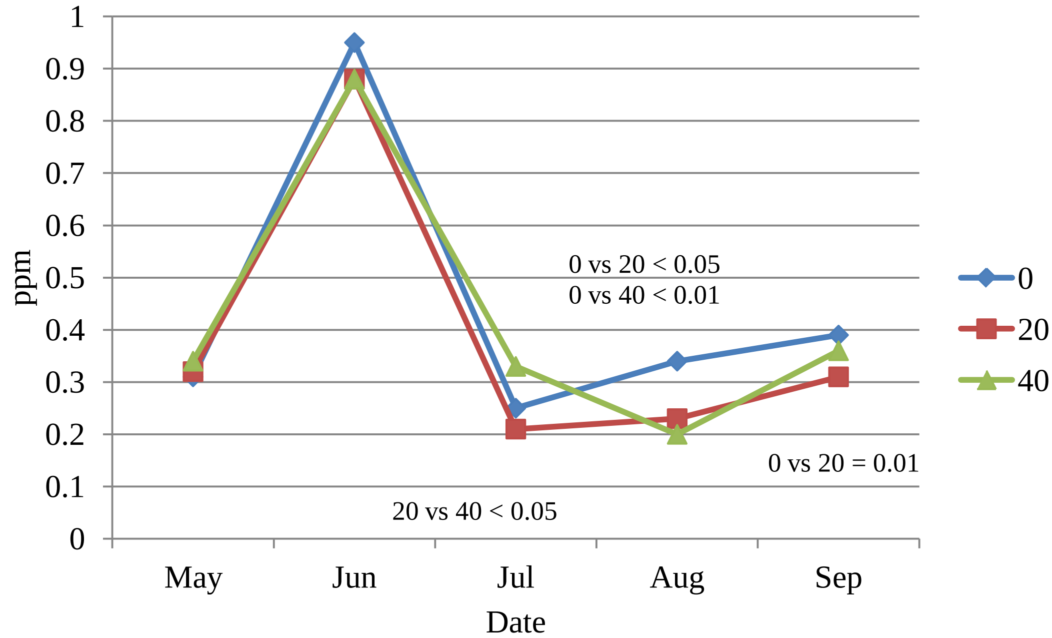


Figure 3.5. Lysergic acid content (ppm) of fecal samples collected from herd managed cows grazing KY-31 tall fescue and supplemented with MTB-100™ at projected consumption rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

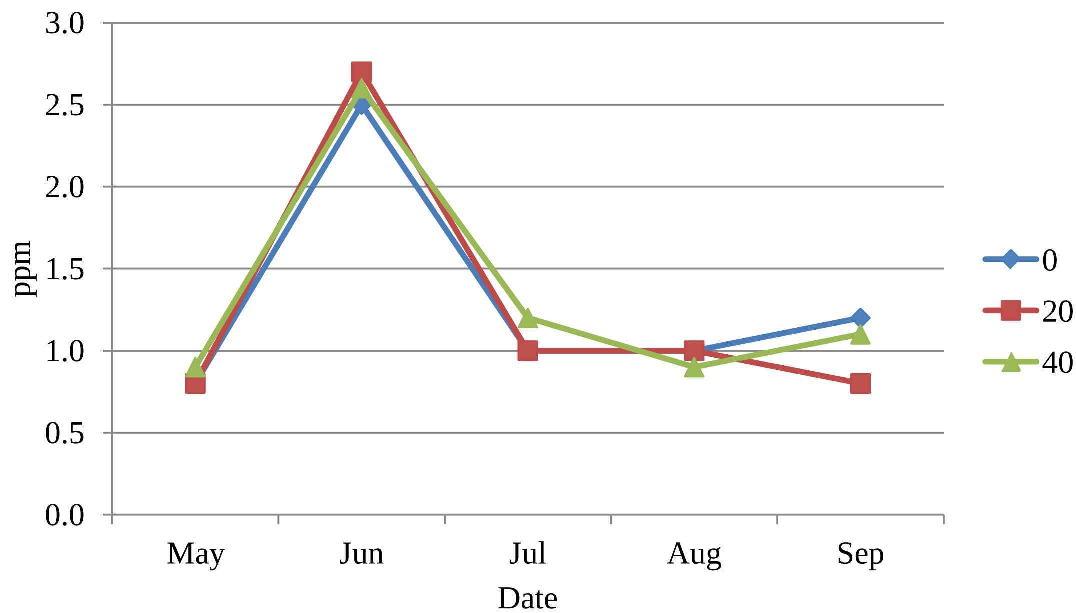


Figure 3.6. Ergovaline content (ppm) of individual plots of KY-31 forage grazed by cows and calves supplemented with projected MTB-100™ consumption rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

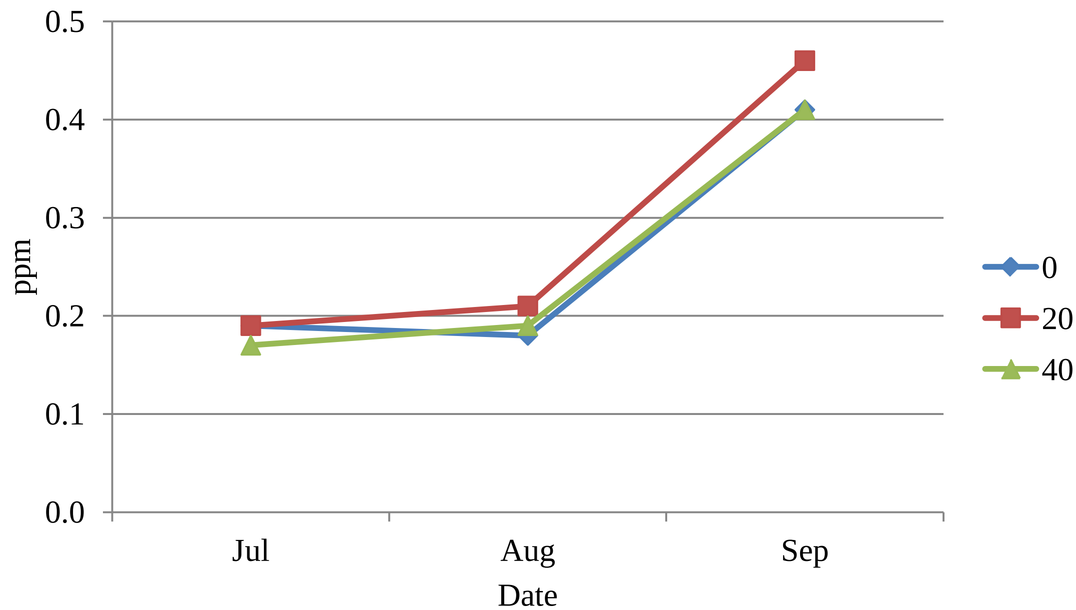


Figure 3.7. Lysergic acid content (ppm) of individual plots of KY-31 forage grazed by cows and calves supplemented with projected MTB-100™ consumption rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

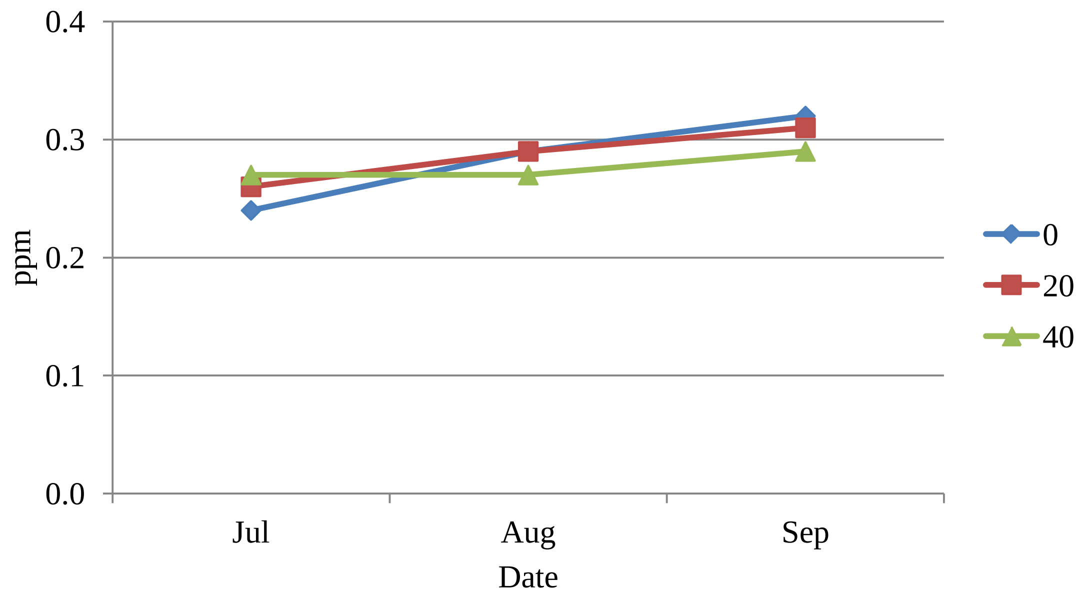


Figure 3.8. Ergovaline content (ppm) of fecal samples collected from cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to September and supplemented with MTB-100™ at projected consumption rates of 0, 20 or 40 $g \cdot cow^{-1} \cdot d^{-1}$.

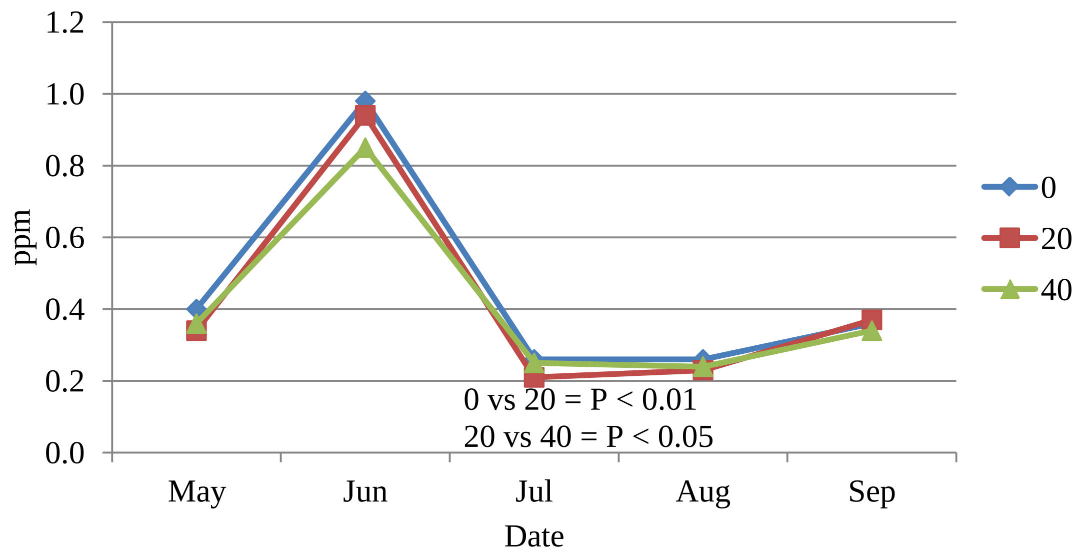


Figure 3.9. Lysergic acid content (ppm) of fecal samples collected from cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to September and supplemented with MTB-100™ at projected consumption rates of 0, 20 or 40 $g \cdot cow^{-1} \cdot d^{-1}$.

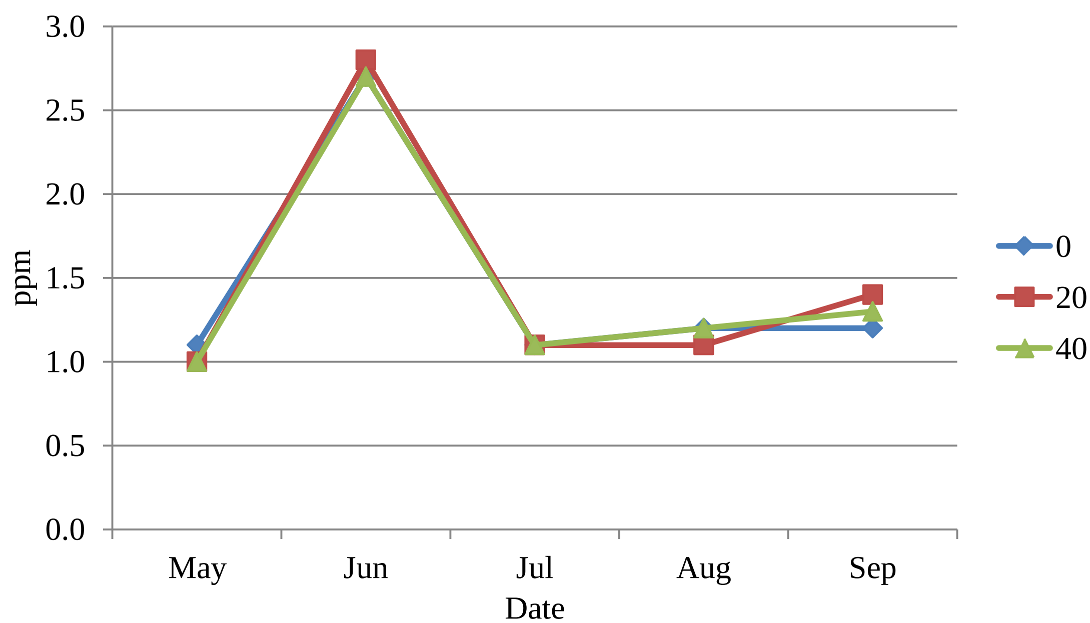


Figure 3.10. Daily mineral consumption (g/cow) of herd managed cows and calves grazing KY-31 tall fescue and supplemented with MTB-100™ at projected intake rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

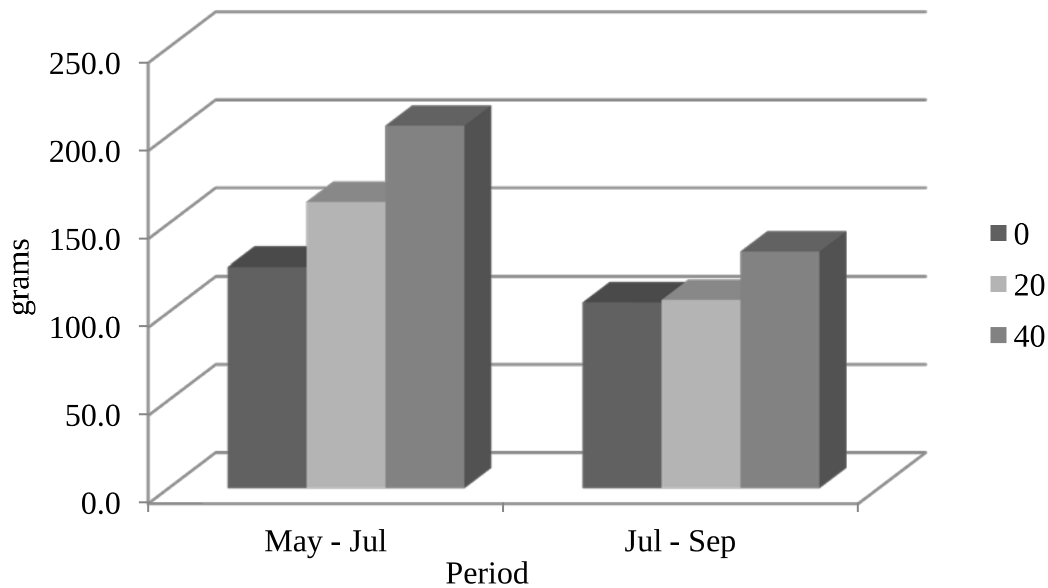


Figure 3.11. Daily MTB-100™ consumption (g/cow) of herd managed cows and calves grazing KY-31 tall fescue and supplemented with MTB-100™ at projected intake rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

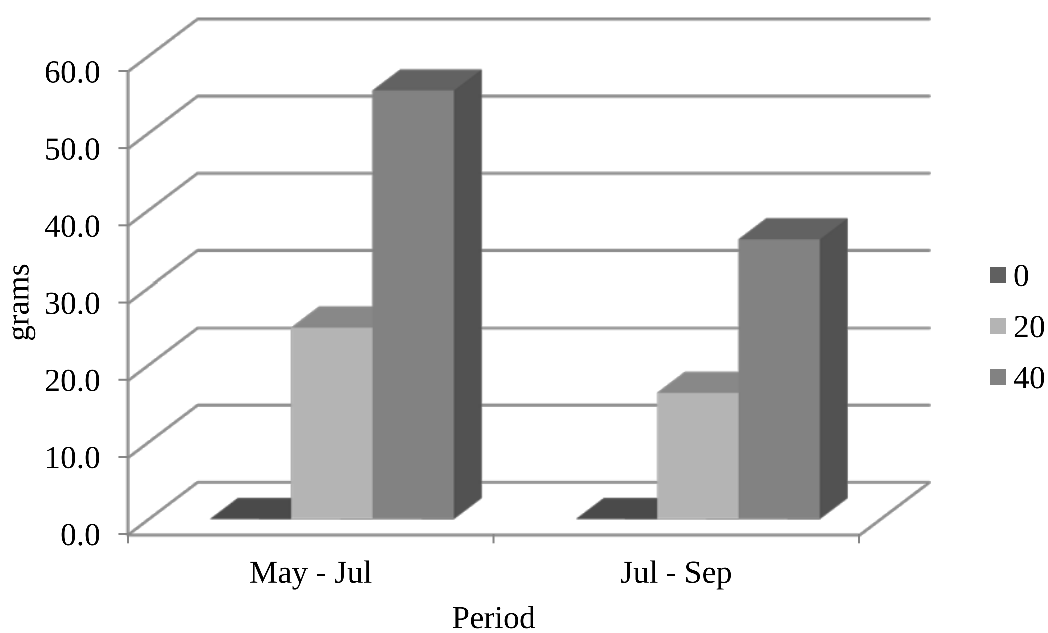


Figure 3.12. Daily mineral consumption (g/cow) of cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to September, and supplemented with MTB-100™ at projected intake rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

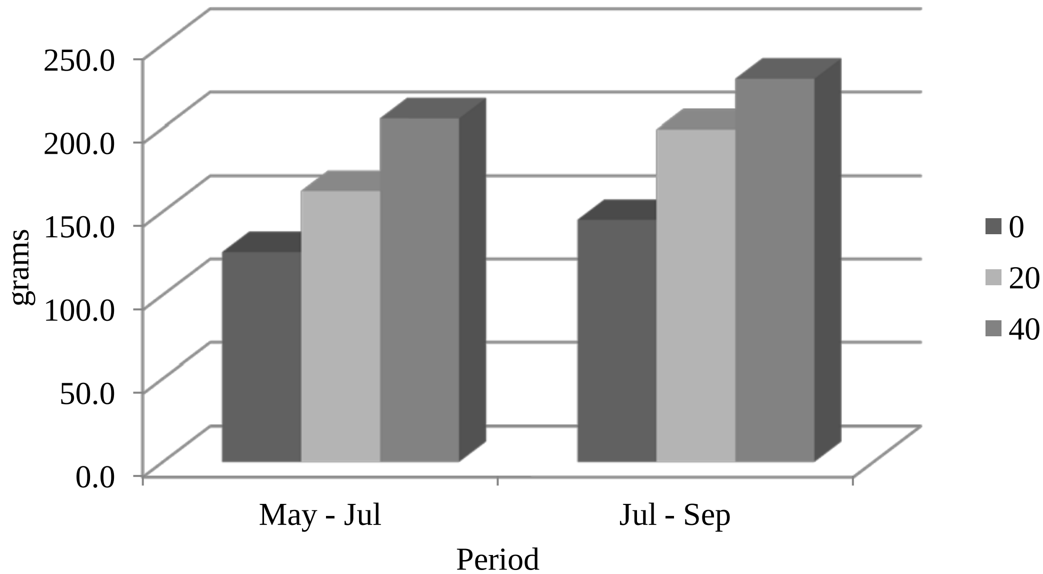


Figure 3.13. Daily MTB-100™ consumption (g/cow) of cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to September, and supplemented with MTB-100™ at projected intake rates of 0, 20 or 40 g•cow^{-1}•d^{-1}.

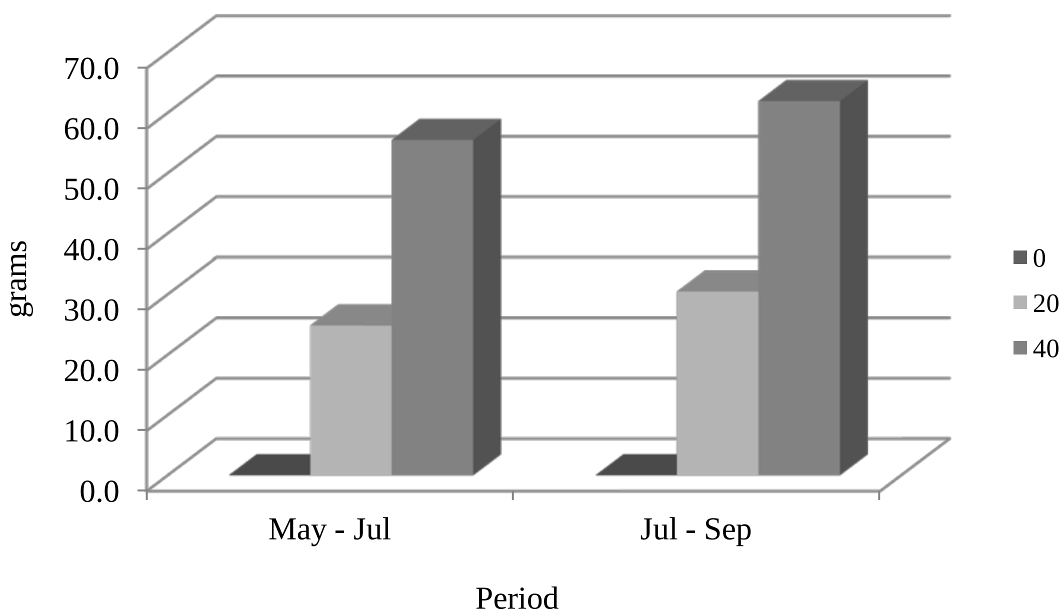


Figure 3.14. Comparison of total rainfall per month and concentration of ergovaline (EV) in KY-31 tall fescue forage collected on specific dates within each month.

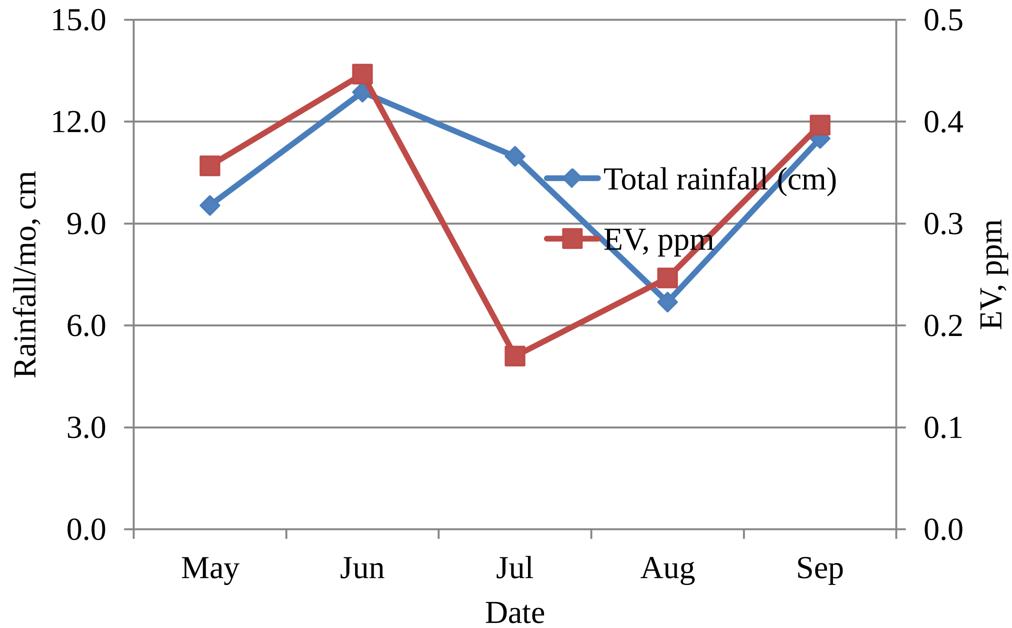
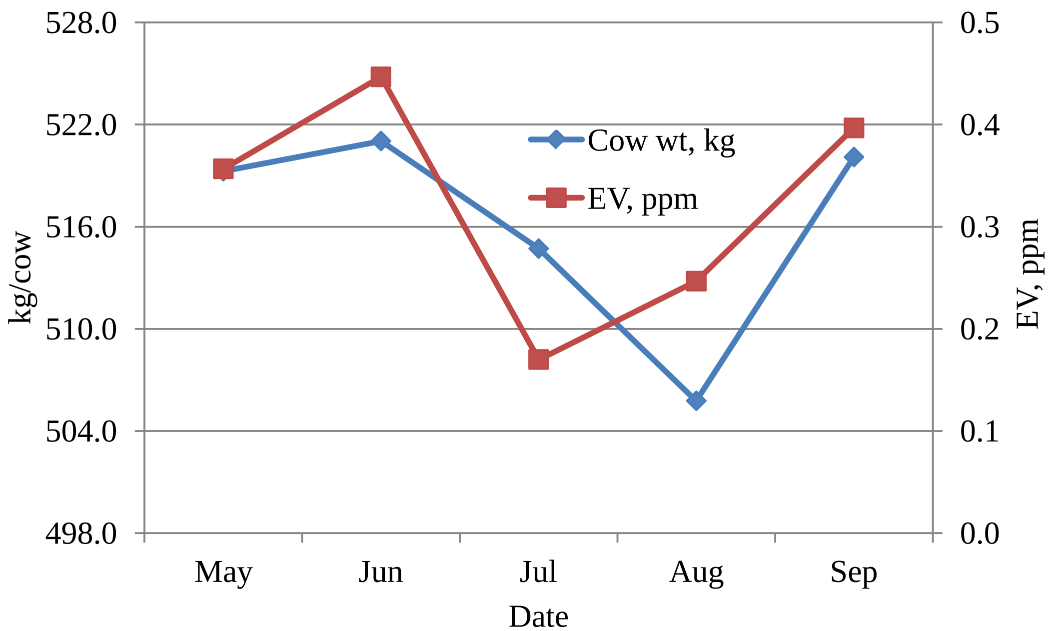


Figure 3.15. Comparison of cow weights and concentration of ergovaline (EV) in KY-31 tall fescue forage during the grazing season.



CHAPTER IV

Experiment 2: Use of MTB-100^{TM}, provided through a mineral mix, in a strategic supplementation plan to alleviate the effects of fescue toxicity when lactating beef cows graze endophyte-infected tall fescue.

Introduction

Previous research by Ely et al. (2006) determined supplementing a glucomannan, FEB-200^{TM} in a corn vehicle fed daily at 0700 h, was successful in improving performance when cow/calf pairs grazed endophyte-infected tall fescue. However, supplementing with a glucomannan for the entire grazing season may not be necessary. The results from Exp. 1 showed EV and LA concentration in forage peaked in June, dramatically decreased in July, maintained a low concentration in August and beg/an to increase again in September. After the initial spike in forage ergot alkaloids in June, cow weights decreased in July and August when ambient temperature was highest. These data support the theory that ambient temperature amplifies effects of fescue toxicity (Hemken et al., 1981; Paterson et al., 1995). Therefore, it may be more critical and economical to supplement at different times during the grazing season when cows are at the greatest risk of suffering from fescue toxicity. Based on the results of Exp. 1 (peak concentrations of EV and LA in May and June, fluctuation in cow weight and BCS, variation in calf gain, and environmental variation from May to October), it appears MTB-100^{TM} (same as FEB-200^{TM}) supplementation during specific times during the grazing season might be as effective as supplementation throughout the season. Therefore, the objective of this study was to evaluate response of lactating beef cows and their calves to a strategic MTB-

100^{TM} supplementation program when they grazed endophyte-infected KY-31 tall fescue forage.

Materials and Methods

The experimental protocol was approved by the Institutional Animal Care and Use Committee at the University of Kentucky.

Study 1: Herd-managed cow/calf pairs

One hundred and five, Angus and Angus x Beefmaster cows and their calves (born in February and March) were randomly assigned to nine, 10.5-ha endophyte-infected (>90%) pastures, stocked with 10 to 16 cow/calf pairs (re-randomized each year) during a 3-yr grazing study. All cow age groups and 2-yr-old heifers were represented in each of the nine pastures in 2009. However, in 2010 and 2011, all 2-yr-old first calving heifers were separated from the mature cows, randomly assigned to three pastures and supplemented with corn daily (1.4 kg/cow). These pastures were removed from the data set due to differences in management. The experimental timeline is summarized in Fig. 4.1. The experiment began on May 5 each year and concluded on October 2 at weaning. The experimental period was divided into three strategic periods: Period 1 (P1) = May 5 to July 5; Period 2 (P2) = July 5 to August 31; Period 3 (P3) = August 31 to October 2. The nine pastures were randomly allotted to treatments supplemented with either 0 or 20 $g \bullet cow^{-1} \bullet d^{-1}$ MTB-100^{TM} within a period (Treatment 1 = 0, 0, 0; Treatment 2 = 20, 0, 20; Treatment 3 = 0, 20, 0; Treatment 4 = 20, 20, 0; and Treatment 5 = 20, 20, 20) and re-randomized each year during the 3-yr study. The treatment schedule is summarized in Table. 4.1. Experiment 1 showed no additional benefit of supplementing with 40 g of MTB-$100^{TM} \bullet cow^{-1} \bullet d^{-1}$ so only 20 g was used. These five supplementation schemes were chosen because Exp. 1 showed ergot alkaloid concentrations were highest in May and June yet cow performance was most affected in July and August when ambient temperature was high but forage ergot alkaloids were low. Therefore it was to be determined if MTB-100^{TM} would be most beneficial to cows during high forage ergot alkaloid infestation (May/June) or when ambient temperatures were high (July/August) or both (May to August). And to determine if there was any effect of strategic supplementation, these schemes were used with both negative and positive controls.

The MTB-100^{TM} supplement was carried in a mineral mix diluted with white salt. Mineral mix composition is provided in Table 4.2. Cows had ad libitum access in a covered feeder placed at the entrance to each pasture. Intakes were calculated every 7 d. Feeders were checked daily and mineral was added as needed. All cows and their calves were individually weighed every 21 d. Cows were assigned a body condition score (BCS) on a scale of 1 to 9 (1 = thin, 9 = obese). Cows and calves were assigned a hair coat (HC) score on a scale of 1 to 10 (1 having short, slick hair; 10 being covered in long hair). Body condition and hair coat scores were assigned by the same two people on each weigh date and averaged. Cow rectal temperatures were recorded on the same days. Fecal samples were collected from pre-designated cows that were less than 6 years of age and carried more than 75% Angus breeding. These cows were selected for their predominant Angus genetics because of their predicted lower tolerance to fescue toxicity than the more tolerant Beefmaster breed (Brown et al., 1992; Browning, 2004). Three to four cows per pasture were selected for sampling. All 2-yr-old heifers (first time calving) were sampled, however only those from 2009 were used. Fecal samples were analyzed for EV and LA concentrations (Aiken et al., 2009). Forage grab samples from the pastures were also collected every 21 d and analyzed for DM (AOAC, 1999), CP (AOAC, 1999), NDF (Robertson and Van Soest, 1981), ADF (Goering and Van Soest, 1970), ash (AOAC, 1999) and EV and LA concentrations (Aiken et al., 2009). Forage and fecal samples were analyzed for EV and LA by the Plant and Soil Science Laboratory at the University of Kentucky. Three metal posts were strategically placed in each pasture. Grab samples were clipped, using trimming shears, every ten steps for two samples in each direction (N, S, E, W) leading away from the post. All samples were freeze dried (- 50°C for 7 to 10 d), ground in a Wiley Mill (1 mm screen) and stored at room temperature in a dry environment until analysis. Bulls were assigned to each pasture on May 5 and removed on July 5 of each year. Pregnancy was determined via palpation by a veterinarian on October 2 (weaning) each year and conception rates were calculated. When the study concluded on October 2, all cows were mixed into a herd and managed on KY-31 tall fescue pasture and supplemented with low quality KY-31 tall fescue hay until the following April. Cows and calves continued to me managed on KY-31 tall fescue pasture as the next grazing season began the following May. Weather variables (ambient temperature, relative humidity and precipitation) were recorded daily at the Williamstown, Ky. weather station. These data were downloaded from the University of Kentucky Agricultural Weather Center (http:wwwagwx.ca.uky).

Study 2: Individually-managed cow/calf pairs

On July 5 of each year, at the conclusion of the breeding season, 21 pre-designated cow/calf pairs were removed from the 10.5-ha pastures and randomly allotted to individual, 1.6-ha plots of equivalent pasture without shade (also re-randomized each year). Cows were supplemented with either 0 or 20 g MTB-100™•cow^{-1}•d^{-1}, depending on supplementation scheme, until October 2. The pre-designated cows met the requirements of 3 to 5 years of age and >75% Angus genetics. Cows continued their respective supplement regimes from this date until calves were weaned on October 2. Data were collected on the cow/calf pairs every 21 d, as described in the herd-managed study. Fecal samples were taken from all individual cows. Mineral intake was determined weekly. Forage grab samples were clipped at 30-step intervals in a crisscross walking pattern from one end of the plot to another. All samples were analyzed using methods described previously.

Statistical Analysis

Cow weight, BCS, HC and rectal temperature data for herd and individually-managed studies were analyzed as a completely randomized design by collection date using PROC GLM of SAS (SAS Institute, 2003). Differences among effects at each collection date were of intrinsic interest. Means were separated using all possible t-tests. The statistical model included fixed effects of year, treatment, cow genetic type and age. Time of day was included as a covariate for rectal temperature. Treatments had fixed effects and consisted of 0 or 20 g of MTB-100^{TM}. Pasture served as the experimental unit and the cow/calf pairs were sampling units in Study 1. Herd-managed pastures were analyzed without the heifer pastures resulting in four replicate pastures for Treatments 1, 2, 4 and 5 and five replicate pastures for Treatment 3, over the 3-yr study. In Study 2, cow/calf pairs were the experimental and sampling units and there were 10, 15, 13, 13 and 12 replicate plots for Treatments 1, 2, 3, 4 and 5, respectively, over the 3-yr study. Pregnancy data were analyzed using Chi-square analyses.

Calf data were analyzed similarly with fixed effects of year, treatment, calf genetic type and calf sex included in the statistical model. Birth date and cow age were used as covariates. Forage, fecal and mineral data were also analyzed by collection date using PROC GLM with year and treatment included in the statistical model. All data reported are least squares means. Significance is indicated at the $P < 0.05$ and 0.01 levels.

Results and Discussion

Study 1: Cow/calf performance

The number of cows and calves allotted to herd-managed pastures across the five treatments is presented in Table 4.3. Cow weights (Table 4.4) were similar across treatments on May 5, July 5 and October 2. Cows in Treatment 4 tended ($P = 0.10$) to weigh more than those in Treatment 2 on August 31. Cows in Treatment 4 gained more weight ($P < 0.05$) in P1 than those in all other treatments. Cows receiving a projected level of 20 g MTB-100^{TM}•cow^{-1}•d^{-1} in Treatment 2, 4 and 5 gained more weight ($P < 0.05$) than those in Treatments 1 and 3 during P1 (May 5 to July 5). Gains in P2 (July 5 to August 31) were not different among treatments although cows in Treatments 3, 4 and 5 (20 g MTB-100^{TM}) gained numerically more weight than those unsupplemented (Treatments 1 and 2). However, from August 31 to October 2, Treatment 2 cows gained more weight ($P < 0.05$) than any other treatment. Cows in Treatments 1, 2, 3, 4 and 5 gained 19.6, 37.2, 30.6, 43.0, and 37.4 kg/cow, respectively, from May 5 to October 2. Most of the beneficial effects of MTB-100^{TM} consumption on total gain occurred during P1. This can be seen in Treatments 2, 4 and 5 when 51, 61 and 53%, respectively, of the total season gain occurred from May 5 to July 5. These results indicate the optimum time to supplement with MTB-100^{TM} may be from May to July compared with July, August and September.

Cow BCS (Table 4.4) were not different among treatments initially (May 5), at the start of P3 (August 31) or at the conclusion of the grazing period (October 2). However, on July 5, Treatment 3 cows had the lowest BCS compared with the highest in Treatment 5 ($P < 0.05$). Period changes were not different among treatments although the most positive numerical changes occurred in P1. Thereafter, BCS of cows in all treatments remained relatively constant. Similar results were found for HC changes. The largest numerical decreases occurred in P1, remained relatively unchanged in P2, and tended to increase in P3. Initially (May 5) rectal temperatures (Table 4.4) were similar. Increases from May 5 to July 5 were not significant even though absolute temperatures varied by treatment on July 5. All rectal temperatures decreased in July and August after the July 5 peak. In addition to treatment effects on cow performance, differences were also found for genetic type, cow age and year.

The number and percent Angus and Beefmaster breeding of herd-managed calves is shown in Table 4.3. In general, calves were 75% Angus and 25% Beefmaster. Weights were adjusted for cow age and calf birth date. Weights, gains and HC scores of calves nursing cows in the five strategically supplemented treatments are shown in Table 4.5. Calf gain in P1 was higher ($P < 0.05$) for Treatment 2 than 5. No statistical differences, due to supplementation strategy, were found for P2 or 3. Total gain/calf for the 150-d grazing season (May 5 to October 2) was 148.8, 151.1, 146.8, 149.0 and 151.8 kg, for Treatments 1, 2, 3, 4 and 5, respectively. Most of the beneficial effects of MTB-100^{TM} consumption on total gain of cows occurred in P1 (Table 4.4). In contrast, only 44, 43, and 40% of total calf gain occurred from May 5 to July 5 for Treatments 2, 4 and 5, respectively, when their dams were consuming a projected level of 20 g MTB-100^{TM}•cow^{-1}•d^{-1}. Change in HC scores of calves was not affected by the strategic MTB-100^{TM} supplementation scheme invoked in this experiment. An analysis of cow and calf performance indicates some benefit to cows when supplemented with MTB-100^{TM}, but little effect on calves was noted.

Year differences ($P < 0.01$) were found for cow weight, BCS, HC and rectal temperature changes. From May 5 to July 5, cows in 2011 gained more ($P < 0.01$) than those in 2009 and 2010. Cow gains from July to August and August to October were not different across treatments. These results differ from year differences that occurred for herd-managed cows in Exp. 1. In the current experiment, cows gained during all three periods while cows in Exp. 1 in general, lost weight from May to July, but compensated for the loss from July to September.

BCS changes from May to July followed weight gain with 2011 gaining more body condition compared with 2009 ($P = 0.06$) and 2010 ($P < 0.01$). BCS changes from July to August did not differ among years. From August to October, 2010, cow BCS did not change, but each cow gained BCS ($P < 0.05$) in 2011. Body condition score change for 2009 was not different from either 2010 or 2011. BCS changes in this study differ from Exp. 1 with cows losing BCS from May to July and gaining from July to September.

Hair coat scores decreased from May to July in all 3 years. However, cows in 2009 and 2011 had greater HC decreases than 2010 ($P < 0.05$). Cows in 2009 increased their HC score from July to August versus the decrease ($P = 0.07$) in 2010. The year effect on HC score changes during P2 was nonsignificant. HC score increased more for cows in 2011 than 2009 ($P = 0.06$) and 2010 ($P = 0.07$) from August to October.

Cow rectal temperatures increased during May to July each year. The 2010 cows had a higher ($P = 0.05$) rectal temperature increase than 2009. Rectal temperature increased in 2011, but this was not different from the other 2 years. Rectal temperature decreased for cows across all years from July to August. However, the largest decrease occurred in 2010 ($P = 0.01$) compared to 2009 and 2011. Temperature changes were not different across years from August to October dates. In general, rectal temperatures of herd-managed cows decreased from May to July in Exp. 1 versus the increase seen in this study. Experiment 1 weather had significant year variations in ambient temperature and relative humidity as well as numerical differences in precipitation. Variations from year to year within an experiment may play an important role in cow and calf response when grazing endophyte-infected tall fescue. Also, differences in weather patterns during Exp. 1 and 2 may explain some of the differences in cow/calf performance observed between experiments. Weather patterns over the current 3-yr study will be discussed later in this chapter.

Year differences ($P < 0.05$) were found for calf weights and HC. Gain from May to July, 2010, was greater than 2009 ($P < 0.05$). Gain in 2011 did not differ from 2009 or 2010. Calf gains differed across years ($P < 0.01$) from July to August with 2009 calves gaining the most followed by 2010 and 2011. Calves in 2011 gained more from August to October than those in 2009 ($P < 0.01$) and 2010 ($P < 0.01$). Hair coat changes were not different across years from May to July, but changes from July to August, 2011, were larger ($P < 0.01$) than in 2009. Hair coat change in 2010 was not different from the other years. However, changes from August to October, 2009 were less in 2009 than 2010 (P = 0.01) and 2011 (P < 0.01).

Genetic type was categorized by the amount of Angus and Beefmaster breeding in cows and calves (Table 4.6). These categories are 1 = ≥ 75% Angus ≤ 25% Beefmaster, 2 = 50% Angus 50% Beefmaster, 3 = 51 to 75% Angus 49 to 25% Beefmaster and 4 = < 50% Angus > 50% Beefmaster. Cows with more Beefmaster breeding (less than 50% Angus; genetic type 4) gained more weight (P = 0.01) during P1 (May 5 to July 5) than 51 to 75% Angus (genetic type 3). This was the period when 58% of all cows were supplemented with MTB-100™ (Table 4.1). These cows also gained more than genetic types 1 (P < 0.05) and 3 (P < 0.01) from July 5 to August 31. Genetic type 4 cows continued to gain numerically more in P3, but differences were not significant.

Although initial BCS differed (P < 0.05) among genetic types, BCS changes occurred only from May 5 to July 5. It was during this period BCS of genetic types 2 and 4 increased more (P < 0.05) than types 1 and 3. This response appears to be related to the weight gain increase (Table 4.4) when 58% of the 184 cows in the study were supplemented.

Initial HC was generally higher (P < 0.05) on May 5 in genetic types 3 and 4. On July 5, August 31 and October 2, cows with 51 to 75% and those with greater than 75% Angus had higher HC scores than genetic types 2 (50% Angus) and 4 (less than 50% Angus) (P < 0.01). Largest numerical decreases in HC score occurred during P1 (P < 0.05). Although some genetic type differences (P < 0.05) occurred in P2, numerical changes from July 5 to August 31 were small when compared with those of P1. There were no statistically significant differences among genetic types for HC changes during P3 (August 31 to October 2).

Rectal temperatures of cows followed a trend similar to HC for May 5, July 5 and August 31 weigh dates. Cows with higher percent Angus breeding (genetic types 1 and 3) had higher ($P < 0.05$) rectal temperatures than types 2 and 4 on all three weigh dates. The 50% Angus 50% Beefmaster cows had lower ($P < 0.05$) rectal temperatures than ≥75% Angus ≤ 25% Beefmaster on October 2. The increase in temperature from May 5 to July 5 was more ($P < 0.05$) for ≥75% Angus ≤ 25% Beefmaster cows than < 50% Angus > 50% Beefmaster even though the latter genetic type had a lower initial temperature on May 5. Rectal temperatures of all genetic types decreased from 0.1 to 0.4°C from July 5 to August 31. For P3 (August 31 to October 2), temperatures of cows with more Beefmaster breeding (genetic types 2 and 4) tended to decrease to lowest actual readings on October 2.

Cows with at least 50% Beefmaster breeding (genetic types 2 and 4) gained more total weight and body condition from May 5 to October 2 than those with more than 50% Angus breeding (genetic types 1 and 3). The majority of the gains occurred during the 61-d period from May 5 to July 5, which constituted only 41% of the grazing season period (May 5 to October 2). Additionally, HC scores of genetic type 2 and 4 cows decreased more and rectal temperatures tended to be lower during the May 5 to July 5 period. These results point to possible benefits of using Beefmaster breeding to combat some fescue toxicity whether supplemented with MTB-100™ or not.

Genetic type categories for calves were the same as the cows. Calves with 51 to 75% Angus breeding weighed heavier (Table 4.7) on May 5 and July 5 than those with greater than 75% Angus ($P < 0.05$), 50% Angus ($P < 0.01$) and less than 50% Angus ($P < 0.01$). On August 31 and October 2 (weaning), calves with 51 to 75% Angus only weighed more than those in genetic types 1 ($P < 0.01$) and 4 ($P < 0.05$). Calves in the 51 to 75% Angus breed group gained more during P1 than types 1 ($P < 0.01$) and 4 ($P < 0.05$). The greater than 75% Angus calves gained less than all other groups ($P < 0.01$) from July 5 to August 31. In P3, calves with 51 to 75% Angus gained more than those in genetic type 1 ($P < 0.05$). Calves with greater than 75% Angus had higher HC scores than genetic types 3 ($P < 0.01$) and 4 ($P < 0.05$) on May 5, July 5 and August 31. Their scores were higher ($P < 0.01$) than all other genetic types on October 2. Calves with less than 50% Angus had lower HC scores than type 3 on July 5, August 31 and October 2 ($P < 0.01$). Calves with less than 50% Angus had a larger change in HC score than genetic types 1 ($P < 0.01$) and 3 ($P < 0.01$) during P1 and type 1 ($P < 0.01$) during P3. No other differences were found for HC changes across genetic types.

Cows were grouped for statistical analysis of age (Table 4.8). The age groups were 1 = 2-yr-old heifers (first time calving), 2 = 3-yr-olds, 3 = 4-, 5-, 6-yr-olds and 4 = 7+-yr-old cows. Cow weights and BCS (Table 4.8) were similar for older cows (groups 3 and 4) on each weigh date. First calf, 2-yr-old heifers weighed less than 3-yr-old ($P < 0.05$), 4-, 5-, 6-yr-old ($P < 0.01$) and 7+-yr-old ($P < 0.01$) cows on each weigh date. They also had lower ($P < 0.01$) BCS than Groups 2, 3 and 4 after May 5. Three-yr-old cows weighed less ($P < 0.01$) than Groups 3 and 4 on each weigh date. They also had lower BCS ($P < 0.05$) except on October 2.

Three-yr-old cows gained more weight in P1 than 2-yr-olds ($P = 0.01$) and 7+-yr-old cows ($P < 0.05$). Also, from May 5 to July 5, 2-yr-olds gained less ($P < 0.01$) body condition than Groups 2, 3 and 4. Heifers gained more ($P = 0.05$) than 7+-yr-old cows from July 5 to August 31 (P2). However, it was the 3-yr-olds that gained more ($P = 0.05$) body condition in P2 than 7+-yr-olds. Two-yr-olds and 3-yr-olds gained more than 7+-yr-old cows ($P < 0.05$) in P3, yet BCS changes were not different across age groups.

Two-yr-old heifers had higher HC ($P < 0.01$) scores than 4-, 5-, 6- and 7+-yr-old cows on each weigh date, but differed from 3-yr-olds only on May 5 and July 5. The heifers tended to have higher ($P = 0.10$) HC scores than 3-yr-olds and 3-yr-olds tended to have a higher HC ($P = 0.06$) score than 7+-yr-old cows on August 31. Three-yr-old cows had higher ($P < 0.05$) HC scores on October 2 than 7+-yr-olds ($P <0.05$). Hair coat loss was less for 2-yr-old heifers in P1 than Group 3 ($P < 0.05$) and 4 cows ($P < 0.01$). The opposite occurred from July 5 to August 31 when HC scores of 2-yr-old heifers decreased more ($P < 0.01$) than all other age groups.

Two-yr-old heifers also had higher ($P < 0.01$) rectal temperatures than all other ages on every weigh date, except October 2. Their temperature was higher ($P < 0.01$) on this date than Groups 3 and 4 only. Rectal temperature of 2-yr-olds increased more ($P < 0.05$) in P1 than all other age groups. This result was followed by a larger decrease in P2 ($P < 0.01$) and P3 ($P < 0.05$) than all other groups. The consistently lower temperatures of cows in Groups 2, 3 and 4 might explain why there was less fluctuation from one weigh date to the next with older cows than with 2-yr-old heifers.

The 2-yr-olds heifer data described above was from year 2009 herd-managed pastures. Due to their low initial weights and BCS scores, the heifers were removed from the rest of the herd at the start of the grazing season in 2010 and 2011 and randomly assigned to three pastures so they could be supplemented with ground ear corn at 1.4

kg•cow^{-1}•d^{-1}. These data were removed from the remainder of the herd-managed data to avoid confounding management variability in the statistical analysis. The 2-yr-old heifers from 2009 were included in the statistical analysis because they were mixed with other ages in the herd-managed pastures. None of the heifers were separated from mature cows in Exp. 1 because they had an initial weight of 471 kg and BCS of 5.4, when entering the breeding season, compared to 442 kg and BCS of 4.1 in Exp. 2. The light weights and low BCS of heifers in Exp. 2 may have contributed to the decreased pregnancy rates that were found in 2009 and will be discussed later in this chapter. Mature cows (4-, 5-, 6- and 7+-yr-olds) of Exp. 2 weighed more than 2- and 3-yr-olds throughout the grazing season. The expected weight and BCS differences between 2-and 3-yr-olds and more mature cows agree with the results of Exp. 1 and Renquist et al. (2006). The ability of the mature cows to maintain heavier weights, higher BCS, lower HC scores and lower rectal temperatures supports the idea age may play a role in susceptibility to heat stress brought about by high ambient temperatures and consumption of endophyte-infected tall fescue. Spiers et al. (2005) stated age is a major determinant of the critical limits of an animal's thermoneutral zone. This suggests older cows that stay in the herd, based on their performance and ability to produce a live calf annually, may have a higher upper critical limit which allows them to tolerate higher ambient temperatures when grazing endophyte-infected tall fescue.

Proximate and EV/LA analysis of forage and feces

Forage samples were collected from pastures to determine if chemical composition was similar across treatments on each weigh date. Concentrations of KY-31 tall fescue ash, CP, NDF and ADF of the herd-managed pastures are presented on a 100%

DM basis in Table 4.9. Pasture samples were collected every 21 days from May 5 to September 10. Due to limited DM production in late September to beginning of October, pasture samples were not collected on the final weigh date (October 2). Ash content was lower ($P < 0.05$) for Treatment 5 than Treatment 2 pastures in May and July and lower than Treatment 4 ($P < 0.05$) in August. Crude protein content was similar for all treatment pastures. Percent NDF was highest in Treatment 2 and 3 pastures but was only different from Treatment 5 pastures ($P < 0.05$) in June. In July, NDF and ADF in Treatment 1 pastures were higher ($P < 0.05$) than Treatment 2 pastures. In August, Treatment 5 pastures were higher ($P < 0.05$) in NDF than Treatment 1, 2 and 3. However, ADF was higher ($P < 0.05$) in Treatment 4 than Treatment 1 and 2. Over the total grazing period, ash and CP were high in May, decreased in June, began to increase in July and August and decreased again in September. Pasture NDF and ADF concentrations were low in May, increased in June, peaked in July, declined in August and increased in September. These pastures were bush-hogged in late July, which could account for some of the changes in forage composition seen from July 5 to August 31. More than two-thirds of KY-31 tall fescue DM production is produced by late June (Roberts et al., 2009). By July, the forage in pastures has matured and is predominately stems and seeds, which are high in NDF and ADF, but low in CP. The pastures are then bush-hogged to clear out the stems and allow regrowth of the immature leaf blades that are higher in CP.

Pasture EV and LA concentrations (ppm) were similar across treatments throughout the grazing season (Fig. 4.2 and 4.3). In Exp. 1, forage EV (Fig. 3.2) concentration peaked in June, decreased in July and increased in August and September. Forage LA (Fig. 3.3) peaked in June and again in August. Unlike Exp. 1, EV was highest in forage on May 5 and gradually decreased on June 15, July 5 and August 31 before it began to increase by September 10. Lysergic acid peaked on June 15, similar to Exp. 1, but declined on July 5 and August 31. Concentration was maintained on September 10. Despite the differences between Exp. 1 and 2, Exp. 2 results support the ideas of Bush and Fannin (2009) who provided evidence that EV of KY-31 tall fescue grown in the transition zone reaches its highest concentration in mid-May. Agee and Hill (1994) reported June EV concentration of tall fescue is only 30 to 50% of that in May. The current results show EV concentration was lower on June 10 than May 5, but not to the extent of Agee and Hill (1994). Forage samples in this experiment were taken at the start of the experiment on May 5. Therefore, forage EV concentration still had potential to increase. The current study also shows forage EV on August 31 was lower than on July 5, which differs from previous research. Bush and Fannin (2009) showed EV begins to accumulate in August, continues to increase in September and peaks a second time in October. At this research unit, the pastures are bush-hogged by August, which removed seedheads and stems to allow for new growth. It is not specified in the literature if or when pastures were clipped, which could explain why the results from this experiment differ from previous studies. Also, rainfall and ambient temperature affects overall forage production of KY-31 tall fescue and, therefore, EV production.

Despite the differences for EV concentrations between experiments, the data do agree with previous research that ergot alkaloid concentrations are highest early in the grazing season in Kentucky. Cows receiving MTB-100™ supplementation gained more weight during the period of high forage ergot alkaloid infestation than those unsupplemented. This supports the idea the time during the total grazing season when

MTB-100^{TM} supplementation is likely to be most beneficial to cow performance is in May and June.

If MTB-100^{TM} binds ergot alkaloids in the rumen to prevent absorption, then cows consuming MTB-100^{TM} should excrete higher levels of EV and LA than those not receiving MTB-100^{TM}. Treatments 2, 4 and 5 cows received the projected 20 g MTB-100^{TM}•cow^{-1}•d^{-1} in the mineral mix (Table 4.1) from May 5 to July 5 as Treatments 1 and 3 received the mineral mix without MTB-100^{TM}. Treatment 3, 4 and 5 cows received MTB-100^{TM} from July 5 to August 31 while those in Treatments 1 and 2 did not. Cows in Treatments 2 and 5 received MTB-100^{TM} from August 31 to October 2 as those in Treatments 1, 3 and 4 went without. Fecal EV and LA concentrations (ppm) for herd-managed cows are shown in Fig. 4.4 and 4.5. Initial fecal EV concentrations (ppm) were similar among treatments on May 5. On June 15, Treatment 5 cows tended to have higher fecal EV concentrations than Treatments 2 ($P = 0.06$) and 4 ($P = 0.07$) even though they were all supplemented at this time. Theoretically, the number of cows selected for sampling should be representative of all cows in each pasture. However it is uncertain how much or how often mineral was consumed by those cows that were selected for sampling. It is possible sample cows in Treatments 2 and 4 had consumed a different amount than those in Treatment 5 which would explain why there was a difference in fecal EV. No treatment differences were found on July 5, August 31 or October 2. However, cows in Treatment 5 had higher fecal EV concentrations on September 10 than those in Treatments 1 and 4 ($P < 0.05$) and tended to have higher levels than Treatment 3 cows ($P = 0.07$). These results were expected since Treatments 1, 3 and 4 did not consume MTB-100^{TM} from August 31 to October 2. Fecal LA was similar across treatments on May 5, June 15, July 5 and August 31, but on September 10, fecal LA concentration was higher for cows in Treatment 4 than for those in Treatments 1 ($P < 0.05$) and 2 ($P = 0.01$) on September 10. Cows in Treatment 3 also had greater fecal LA than those in Treatment 2 ($P < 0.05$) on September 10. Treatment 5 cows were supplemented throughout the grazing season, but had lower LA output on October 2 than Treatment 1 ($P = 0.06$), 2 ($P = 0.06$), 3 ($P = 0.07$) and 4 ($P = 0.08$).

Fecal EV and LA concentrations across treatments followed a similar pattern to forage concentrations throughout the grazing season. Cows consuming MTB-100™ throughout the study (Treatment 5) had the second highest weight gain from May 5 to July 5 and had the highest numerical fecal EV and LA concentrations. Treatment 4 and 2 cows also received MTB-100™ during P1 and ranked 1 and 3 in weight gain, yet had the lowest fecal EV concentrations. Ergot alkaloid concentrations are highest in May and June during peak forage production (Bush and Fannin, 2009; Roberts et al., 2009). MTB-100™ may have succeeded in binding the ergot alkaloids as evidenced by the increased weight gain of supplemented cows. The physiological aspects of ergot alkaloid digestion and absorption are not yet understood. It is possible EV could have been converted to another form that could not be accounted for as suggested by Strickland et al. (2009). On the other hand, LA could have been primarily excreted in the urine instead of the feces as reported by Schultz et al. (2006). Both scenarios are speculative since the methods of absorption and elimination of ergot alkaloids in the ruminant are not well defined.

Study 2: Cow/calf performance

The number and genetic type of cows and calves, and age of cows, managed in individual KY-31 tall fescue plots and strategically supplemented with MTB-100™ are presented in Table 4.10. Table 4.11 shows cow weights, BCS and HC scores were similar across strategic supplementation schemes on May 5, July 5, August 31 and October 2. The only difference found for rectal temperature was on October 2 when negative control (Treatment 1) cows had higher temperatures than those in Treatment 2.

From May 5 to July 5, when pre-designated individual cows were managed with the rest of the herd, Treatment 3 cows gained less weight (Table 4.11) than supplemented cows in Treatment 2 ($P = 0.09$) and Treatment 4 ($P < 0.05$). Pre-designated individuals were removed from the herd and placed in their assigned plots on July 5. When managed individually from July 5 to August 31, cows in Treatment 4 gained less than those in Treatment 1 ($P < 0.01$), 2 ($P < 0.05$), 3 ($P < 0.05$) and 5 ($P = 0.10$). However, from August 31 to October 2, Treatment 4 cows gained weight while those in the negative control (Treatment 1) ($P = 0.09$) and Treatment 3 ($P = 0.08$) lost weight. Cows in Treatments 1, 2, 3, 4 and 5 gained 33.9, 37.9, 30.7, 32.4 and 32.4 kg/cow, respectively from May 2 to October 2. The herd-managed cows showed the most beneficial effects of MTB-100^{TM} consumption on total gain occurred during P1. Similar to the rest of the herd-managed cows, pre-designated individuals in supplemented Treatments 2, 4 and 5 had 55, 76 and 55% of the total season gain occur from May 5 to July 5. In contrast, cows in Treatment 3 had 69% of the total season gain occur when supplemented from July 5 to August 31. Also, 55% of the total season gain for Treatment 1 cows occurred during P2. These differences could be attributed to the fact pre-designated individual cows were assigned to new ungrazed pastures on July 5.

Positive control (Treatment 5) cows gained more ($P = 0.08$) body condition than unsupplemented Treatment 3 cows when managed with the herd during P1. In P2, Treatment 4 cows lost body condition compared with those that gained in Treatment 1 ($P < 0.05$), 2 ($P = 0.08$) and 3 ($P < 0.01$). Also from July 5 to August 31, Treatment 3 cows increased their BCS whereas the BCS of Treatment 5 cows did not change ($P = 0.05$). However, in P3, Treatment 3 cows lost body condition while those in Treatment 4 gained ($P < 0.05$). There were no HC differences across treatments in P1, P2, or P3. Rectal temperatures did not differ across treatments during P1 or P3. However, from July 5 to August 31, Treatment 2 cows had a larger ($P = 0.05$) decrease in rectal temperature than those in Treatment 4.

Weight changes in pre-designated individually-managed cows, while in their herd-managed pastures from May 5 to July 5, were similar to the rest of the herd-managed cows (Table 4.4) with supplemented Treatments 2, 4 and 5 gaining more weight than those unsupplemented (Treatments 1 and 3). However, after cows were removed from their respective pastures on July 5 and assigned to individual plots, those in Treatments 1 through 4 performed opposite to the remaining herd-managed cows in the same treatments. Cows in Treatments 1, 2 and 3 gained 2 to 3 times the weight of the herd-managed cows while those in Treatment 4 gained less. Weight changes in P3 were similar for individual and herd-managed cows across treatments, except Treatment 2 individually-managed cows gained less than those in herd-managed. Body condition score changes followed the same trends as weight changes for individual and herd-managed cows. Hair coats and rectal temperature changes for individually-managed cows responded similarly to those that were herd-managed (Table 4.4).

All herd and individually-managed cows in Exp. 1 (Table 3.3 and 3.10) lost weight and body condition from May to July, but compensated for their weight loss from

July to September. However, Exp. 2 cows gained weight throughout the study with the greatest gain occurring from May to July. Initially, cows in this experiment (Table 4.4 and 4.11) weighed 504 and 506 kg with an average BCS of 4.8 and 4.7 across treatments in herd and individually-managed pastures, respectively. These same cows weighed 531 and 539 kg with a BCS of 5.3 and 5.1 at the conclusion of the grazing season. Cows in herd and individually-managed pastures of Exp. 1 (Table 3.3 and 3.10) weighed heavier initially at 519 and 537 kg and had a higher BCS of 5.6 and 5.9, respectively. These cows had a final weight of 520 and 538 kg and a BCS of 5.3 and 5.5 for herd and individually-managed pastures, respectively. According to Parish and Rhinehart (2008), cows with a BCS of 4.7 to 4.8 would need to gain 38 kg to increase their BCS by 1.0. In doing so, this would put Exp. 2 cows in the same weight range and BCS as Exp. 1 cows on the initial weigh date. These differences may account for some of the differences in performance between these two experiments.

Calf weights were lower initially on May 5 for Treatment 2 than Treatments 1 and 4 ($P < 0.05$) when assigned to their respective herd-managed pastures (Table 4.12). Otherwise, calf weights and gains were not different for any other weigh day or period across treatments when individually-managed. However, overall gain from May 5 to October 2 for calves nursing cows in the positive control (Treatment 5) was 143.1 kg compared with 129.5 kg for those in the negative control (Treatment 1). Calves in strategic supplementation schemes 20, 0, 20 (Treatment 2), 0, 20, 0 (Treatment 3) and 20, 20, 0 (Treatment 4) gained 137.0, 137.8 and 140.4 kg, respectively, all of which were greater than the negative control (0, 0, 0). This evidence suggests supplementing cows with MTB-100^{TM} may improve calf gain. No differences were found for calf HC scores and HC changes across treatments.

Year differences ($P < 0.05$) were found, regardless of strategic supplement treatment, for individually-managed cow weight, BCS, HC and rectal temperature changes. These variables had similar trends that occurred across years for pre-designated individual cows when compared to those in herd-managed pastures. Pre-designated individually-managed cows gained more weight ($P < 0.01$) and body condition ($P < 0.01$) in 2011 than those in 2009 and 2010 while being managed with the herd from May to July. From July to August, the 2009 individually-managed cows gained more weight ($P < 0.01$) and BCS ($P < 0.05$) than those in 2010 and 2011. Cow gains from August to October were minimal and did not differ across years. However, individually-managed cows in 2011 increased BCS while those decreased in 2009 and 2010 ($P < 0.05$). Performance of individually-managed cows was similar to herd-managed during this time.

In general, HC scores decreased and rectal temperatures increased for pre-designated individuals from May to July, across all three years. This was consistent with the rest of the herd during this period. There were no year differences in P1 for pre-designated individuals. In contrast to herd-managed cows, hair coat scores increased from July to August, but year differences were nonsignificant. Rectal temperature changes during P2 were similar for herd and individually-managed cows. A larger decrease in temperature was found in 2010 than in 2009 ($P < 0.05$) and 2011 ($P < 0.01$). HC scores increased more from August to October in 2011 than 2009 ($P < 0.01$) and 2010 ($P < 0.05$). These changes were consistent with the herd-managed cows. The rectal temperatures of the 2011 cows decreased more ($P < 0.05$) from August to October than those in 2009 and 2010. There were no differences across years for herd-managed cow rectal temperature changes during this period.

Year differences were also found for calf gains and HC changes. Calves gained more weight ($P = 0.01$) from May to July, 2011 than in 2009 when nursing cows in herd-managed pastures. Gains for 2010 were similar to those of 2009 and 2011. Hair coat changes were similar across years in P1. In contrast, calf weight gains from July to August were higher in 2009 than 2010 ($P = 0.07$) and 2011 ($P < 0.01$). However, the HC of 2011 calves decreased as those in 2009 and 2010 increased ($P < 0.01$). Weight gains from August to October were different across years ($P < 0.01$) with calves gaining the most in 2011 and the least in 2010. HC increased the most ($P < 0.05$) during P3 for calves in 2011 compared with those in 2010 and 2011. Calf weight gains corresponded with cow weight gains across years. That is, cows that tended to gain more and increase in BCS tended to produce calves that gained more within a period and for the entire grazing season. In general, these calves performed similarly to those managed in the herd throughout the grazing season.

Twenty-one cows were pre-designated for assignment to individual 1.6-ha plots of endophyte-infected tall fescue each year before initial allotment to herd-managed pastures. According to Brown et al. (1992) and Browning (2004*)* *Bos taurus* breeds are less heat tolerant than *Bos indicus* breeds and would allow greatest effects of heat induced fescue toxicity to be observed. Therefore, pre-designated cows were selected based on a genetic type ≥ 75% Angus ≤ 25% Beefmaster. Actual percentages of each are shown in Table 4.10. In addition, Exp. 1 showed older cows (7+-yr-olds) maintained lower rectal temperatures throughout the grazing season. The fact that these cows remained in the herd to become this age attests to their ability to resist some fescue toxicity effects. So, cows assigned to individual plots on July 5 each year were between 3 and 6 years of age (Table 4.10). These ages were divided into two groups (Table 4.13) with 3-yr-olds in Group 2 and 4-, 5-, and 6-yr-olds in Group 3. Cows in Group 3 weighed more and had higher BCS on all weigh dates than Group 2 ($P < 0.01$). There were no cow age differences for weight and BCS changes from one weigh date to the next although total gain from May 5 to October 2 was 29.9 vs. 37.0 kg/cow for Groups 2 vs. 3. Three-yr-old cows had higher HC scores on May 5 ($P < 0.01$) and August 31 ($P = 0.04$), but there were no differences found for HC changes. Neither rectal temperatures nor changes differed between the two age groups on any weigh date or during any period.

Proximate and EV/LA analysis of forage and feces

Forage samples were taken from plots to determine if chemical composition was similar across treatments on each weigh date. Individually-managed plot forage analysis of samples collected on July 5, August 31 and September 10 is shown in Table 4.14. Percent ash and NDF, on a 100% DM basis, were not different across treatments on any collection date. Crude protein was higher in Treatment 3 plots than in Treatment 2 ($P < 0.05$) and 4 ($P = 0.05$) on August 31 and Treatment 2 ($P = 0.01$) on September 10. Treatment 3 plots were lower in ADF than Treatment 2 ($P < 0.05$) and 5 ($P < 0.01$) on September 10. Although absolute values of herd and individually-managed pasture forage (Table 4.9 vs. 4.14) were numerically different, changes from July to September were similar.

Figure 4.6 shows the forage EV concentrations (ppm) across treatments for individually-managed plots. Theoretically, forage from all plots should have had equal EV concentration, much like ash, CP, NDF and ADF (Table 4.14), because all plots had been uniformly fertilized, bush-hogged, and grazed by nonexperimental yearling heifers prior to the initial sampling on July 5. Finding that forage in Treatment 4 (20, 20, 0) plots had less EV, initially, than Treatment 1 (0, 0, 0) and 3 (0, 20, 0) plots might be attributed to variation in sampling procedures or laboratory analysis variability. Differences in the forage sampled could have been a result of grazing pressure and/or forage maturity. All treatment plots were similar on August 31. However, on September 10, Treatment 3 had higher ($P < 0.05$) EV than Treatment 4 and tended to be higher ($P = 0.08$) than Treatment 5. Individual plot LA concentrations (ppm) are presented in Fig. 4.7. Concentrations were similar across treatments on July 5, August 31 and September 10. The individual plot forage EV and LA concentration patterns were similar to those of herd-managed pastures with EV concentrations being higher in July, decreasing in August and increasing in September (Fig. 4.2). Forage LA concentrations were higher in July and decreased in August where they remained fairly consistent in September (Fig. 4.3).

Fecal EV and LA concentrations (ppm) for individually-managed cows are shown in Fig. 4.8 and 4.9. Fecal samples were collected every 21 days from May 5 to October 2 to relate fecal ergot alkaloid concentrations to that of the forage. By the conclusion of the study on October 2, the amount of forage DM production was minimal so forage samples were not collected on the final weigh date even though fecal samples were collected. Note fecal samples collected on May 5 and June 15 were taken from herd-managed pastures while the pre-designated individual cows were herd-managed. The July 5 samples were taken as they were removed from herd-managed pastures and randomly assigned to individual plots. If MTB-100^{TM} is to be successful at binding ergot alkaloids, then cows supplemented with 20 g MTB-100^{TM} should have higher fecal concentrations of EV and LA. Although no treatment differences were found on July 5 or August 31, Treatment 1 (negative control) cows tended to excrete feces containing a lower concentration of EV on September 10 than those in Treatment 3 ($P = 0.08$) and 5 ($P = 0.07$). Both of these treatments were supplemented with MTB-100^{TM} in July and August. Treatment 5 (positive control) cows continued to excrete feces with higher levels of EV and LA than those not supplemented with MTB-100^{TM} in Treatment 4 ($P = 0.08$) and 3 ($P = 0.09$) on October 2.

Fecal EV and LA concentrations across treatments of individually-managed cows followed similar patterns as herd-managed cows and reflected forage ergot alkaloid concentrations. Fecal ergot alkaloid concentrations decreased from July 5 to August 31 before increasing through September and into October. Despite not having forage ergot alkaloid concentrations for October 2, it can be surmised, based on Bush and Fannin's (2009) EV production curve, forage EV and LA concentrations had also increased.

The results of this experiment show MTB-100^{TM} had little effect on increasing EV and LA concentrations in the feces of supplemented cows. However, two of the three treatments (2 and 4) of individual cows that were supplemented from May to July, while in herd-managed pastures, gained numerically more weight than the two unsupplemented treatments (1 and 3). This response was similar for the herd-managed cows and suggests MTB-100^{TM} supplementation did improve performance. However, no differences were found for fecal EV or LA excretions. After the pre-selected individuals were allotted to their respective plots on July 5, the only differences in fecal ergot alkaloid excretions occurred in September and October following the final strategic supplementation change. Despite Treatment 5 cows having higher fecal excretions of EV in September and both EV and LA in October, weight changes during P3 were not different across treatments (Table 4.11). A reason for this could be explained by the fact that most of the weight gained by all cows in all treatments occurred earlier from May to July when individual cows were managed as members of a herd (Table 4.11). This period was concurrent with peak forage ergot alkaloid concentrations (Fig. 4.2 and 4.3). The mineral mix that carried MTB-100^{TM} was provided ad libitum so daily intake can only be estimated. Since fecal samples were taken once every 21 d, it is plausible the time samples were taken relative to MTB-100^{TM} consumption could provide some variability in fecal ergot alkaloid concentrations on the sampling date.

Pregnancy rates

At the conclusion of the grazing period in 2009, cows were pregnancy checked by rectal palpation performed by a licensed veterinarian. Of thirty, 2-yr-old heifers, only 16 were determined pregnant (53%). Pregnancy rates for age groups 2 (3-yr-olds), 3 (4-, 5-, 6-yr-olds) and 4 (7+-yr-olds) in herd-managed pastures were 66.7%, 100% and 94.4%, respectively. Possible reasons for the low pregnancy rate of first calf heifers were low body weight and BCS during the breeding season from May 5 to July 5. While cow body weight and BCS could have resulted from poor nutrition prior to and immediately after calving, some of the effect may have been contributed by fescue toxicity. Table 4.8 shows these data along with high HC scores and rectal temperatures on May 5 and July 5. Fig. 4.2 and 4.3 show high levels of EV and LA in the forage during the May 5 to July 5 breeding season. Cows in all treatments also tended to excrete feces with high EV and LA levels from May to July (Fig. 4.4 and 4.5).

DeRouen et al. (1994) stated 2-yr-old heifers calving for the first time have a high demand on their body reserves and, therefore, should have a BCS $\geq$ 6 at calving to optimize postpartum reproductive performance. Dziuk and Bellows (1983) and Richard et al. (1986) concluded multiparous cows should have a minimum BCS of 5 at calving time. Maintenance, lactation and cow and calf growth take priority for nutrient usage over reproduction (Yates and Schoonover, 1982). Therefore, it is essential for first calving heifers to have higher BCS at calving than multiparous cows, which have already reached maturity. Because of the decreased reproductive performance in 2009, 2-yr-old heifers in 2010 and 2011 were separated from the rest of the herd and managed in three pastures supplemented daily with 1.4 kg of ground ear corn/heifer to increase weight and BCS before and during the next breeding season. Pregnancy rates for 2-yr-old heifers were improved to 87 and 80%, respectively, in 2010 and 2011. However, these pastures were not included in the statistical analysis due to the differences in management. Over the 3-yr study, pregnancy rates for Treatments 1, 2, 3, 4 and 5 were 88%, 82%, 86%, 81% and 86%, respectively (NS) for herd-managed cows. Pregnancy rates for age groups 1, 2, 3 and 4 were 53% (2009 only), 82%, 94% and 89%, respectively ($P < 0.01$). Pregnancy rates of genetic types 1 ($\geq$ 75% Angus), 2 (50% Angus), 3 (51 to 75% Angus) and 4 (< 50% Angus) were 81%, 100%, 83% and 90%, respectively (NS). No pregnancy rate differences across treatments were found for individually-managed cows (1= 90%, 2 = 80%, 3 = 92%, 4 = 84% and 5 = 83%). Likewise, no treatment differences were found for age or genetic type of individually-managed cows.

Mineral consumption

Target mineral consumption was 85.2 to 113.6 g and MTB-100™ consumption was targeted at 20 g•cow^{-1}•d^{-1}. The composition of the mineral mix is shown in Table 4.2. Cows had ad libitum access to the mineral mix. Therefore MTB-100™ consumption was not controlled. Actual mineral and MTB-100™ consumption for herd-managed cows is graphed in Fig. 4.10 and 4.11. Target mineral consumption and MTB-100™ was exceeded from May to July and July to August. Mineral consumption by herd-managed cows during P1 and 2 did not differ across treatments. Mineral consumption ranged from 129.4 (Treatment 5) to 168.4 g (Treatment 1) in P1 and 120.5 (Treatment 4) to 177.6 g (Treatment 1) in P2. MTB-100™ consumption in P1 was 22.3, 22.6 and 22.0 g for Treatments 2, 4 and 5, respectively. From July to August, MTB-100™ consumption was 28.9, 20.5 and 23.3 g for Treatments 3, 4 and 5, respectively. From August 31 to October 2, cows in the negative control (0, 0, 0) consumed more mineral on a daily basis than those in Treatment 2 ($P = 0.07$), 4 ($P = 0.09$) and 5 ($P < 0.05$). Mineral mix consumption decreased from August to October for Treatments 2, 4 and 5 (113.2, 144.7 and 104.4 g, respectively), yet stayed within range of targeted consumption. However, MTB-100™ consumption was slightly lower than targeted amount for Treatments 2 and 5 (19.2 and 17.7 g, respectively).

Mineral and MTB-100™ consumption by individually-managed cows is presented in Fig 4.12 and 4.13. Note the daily mineral consumption from May to July by individually (Fig. 4.12) managed cows was the same as those managed in a herd (Fig. 4.10) because all cows were herd-managed during this period. Mineral consumption in the individual plots did not differ among treatments at any time during the grazing season. However, mineral mix and MTB-100^{TM} consumption nearly doubled when cows were assigned to individual plots after July 5. The mineral mix consumption ranged from 197.8 (Treatment 4) to 257.1 g (Treatment 3) during P2 and 215.6 (Treatment 3) to 278.4 g (Treatment 2) during P3. MTB-100^{TM} consumption during P2 was 43.7, 33.9 and 43.6 g for Treatments 3, 4 and 5, respectively. MTB-100^{TM} consumption during P3 was 47.3 and 42.0 g for Treatments 2 and 5, respectively.

Because cows had ad libitum access and daily consumption patterns were not monitored, when, how often or which cows in the herd-managed pastures actually consumed MTB-100^{TM} could not be determined. Although daily consumption per cow was more precise for individually-managed cows, Ely et al. (1991) showed erratic consumption patterns when animals are managed in individual plots of endophyte-infected KY-31 tall fescue. It was concluded by Evans and Dawson (2007) that maximum binding of ergotamine by the yeast cell wall, Mycosorb, occurs 1.5 hours after incubation. Because mineral/MTB-100^{TM} consumption patterns were not strictly monitored, it is not known when the cows consumed MTB-100^{TM} in relation to grazing time or, for herd-managed pastures, how many of the cows actually consumed mineral each day. Therefore, a lack of response to the treatment could be due to cows not receiving enough mineral at the appropriate time to benefit from the MTB-100^{TM} supplementation.

Weather

Experiment 1 demonstrated significant yearly variations in weather occurred during the 3 years. The differences in weather patterns from year to year can contribute to the year differences found in the cow/calf performance data, especially when symptoms of fescue toxicity are amplified by high environmental temperatures. Experiment 1 showed weights of cows decreased, regardless of treatment, during the months of July and August when the ambient temperature was highest even though EV concentration in the forage was at its lowest. The average maximum temperature (°C), total precipitation (cm), and maximum relative humidity (%) for each month of the grazing period in the current experiment are presented in Table 4.15. Average maximum temperature was similar across years for May and June. Ambient temperature was lower in July and August, 2009 ($P < 0.01$) than 2010 and 2011. Highest temperatures occurred in August and September of 2010 ($P < 0.01$). Monthly precipitation was highest in May and June of all 3 years. Total precipitation in July, 2011 was 7.7 and 9.7 cm lower than in 2009 and 2010. August, 2010 had numerically less total rainfall than 2009 and 2011. The largest deficit occurred in September, 2010. Maximum relative humidity was highest in each month of 2010. Humidity was higher in May, 2010 than 2009 ($P < 0.05$) and 2011 ($P < 0.01$). June, 2010, humidity was higher ($P < 0.05$) than June, 2011. July, 2010, had a higher reading than 2009 ($P < 0.01$) and 2011 ($P < 0.01$). Humidity was higher for August, 2010, when compared to 2011 ($P < 0.05$) and September, 2010, was higher than 2009 ($P < 0.01$).

In Exp. 1, relative humidity followed the same pattern as monthly precipitation (Table 3.14). The months that had the greatest amount of rainfall typically had higher humidities. The only exception occurred in July, 2007, which had more rainfall than 2006 and 2008, yet had the lowest maximum relative humidity. Humidity in Exp. 2 did not follow the same trends. Relative humidity varied monthly with precipitation. August and

September of 2010 had the lowest amount of rainfall of the study, yet had higher humidities.

Experiment 1 showed a direct relationship between amount of rainfall and EV concentration in the forage consumed by cows of herd-managed pastures (Fig. 3.14). Figure 4.14 shows a similar graph relating to Exp. 2. This figure shows how rainfall decreased in June and July, but increased in September, as did EV in the forage. Also, Fig. 3.15 of Exp. 1 showed herd-managed cow weights decreased in July and August during the hottest months of the grazing season after the cows had consumed the forage containing the highest level of EV in June. Indications pointed to weight loss even one to two months after maximum EV consumption. In contrast, Exp. 2 cow weights were lowest when forage EV concentration was highest in May (Fig. 4.15). Thereafter, weights gradually increased as forage EV decreased. This difference could be attributed to environmental variation between Exp. 1 and 2.

Hemken et al. (1981) found cows had lower dry matter intakes, smaller weight gains, higher rectal temperatures and increased respiration rates in high ambient temperatures (31 to 35°C) compared with medium temperatures (21 to 23°C). On average, ambient temperature by month was higher in Exp. 1 than Exp. 2 with the highest temperature occurring in August (Exp. 1: 31°C and Exp. 2: 29°C). Table 4.16 shows how many days during the hottest months (July and August) of the grazing period of each experiment that ambient temperatures reached within 31 to 35°C and how many days exceeded 35°C. 46% of the days in July of Exp. 1 were above 31°C compared to 39% of Exp 2. Whereas, 61% of the days in Aug of Exp 1 were above 31°C compared to 32% in Exp. 2. Forage EV concentrations were also higher for Exp. 1 in June, August and

September (Fig. 3.2 vs. 4.2) and LA concentrations were greater in May July, August and September (Fig. 3.3 vs. 4.3). In general, cows lost more weight in Exp. 1 (Fig. 3.15), from July and August, than Exp. 2 (Fig 4.15). The purpose of comparing the different weather patterns between experiments is to show a possible explanation as to why cows responded differently in Exp. 1 versus Exp. 2. Fescue toxicity may have been more severe in Exp. 1 cattle which would explain the decrease in weights from July to August as well as decreased mineral intake (Fig. 3.10). This suggests the ambient temperature during Exp. 2 may not have exceeded the high temperatures discussed by Hemken et al. (1981) over a long enough period of time to induce severe symptoms of toxicity in cows grazing endophyte-infected tall fescue pasture. It is proposed lower ambient temperatures during Exp. 2 allowed cows to gain weight and increase BCS over the grazing period in contrast with typically decreased performance associated with fescue toxicity.

Implications

The results of this study show cows that were supplemented with MTB-100™ at some point during the grazing season performed better than those that did not receive any. Therefore, there is some advantage to cows consuming MTB-100™. According to these results, cows benefit the most when supplemented during breeding (May/June) as well as during the hottest months (July/August) of the grazing season. However, it is clear not all animals will benefit from supplementation. Variability in the environment and mineral intake makes it difficult to assess the efficacy of MTB-100™ on cow and calf performance when managed in a herd. While it is economically feasible to include MTB-100™ in mineral mix, it does not guarantee all cows will consume it daily. Therefore from a producer's standpoint, it may not be practical to provide MTB-100™ in a mineral mix. Additional research is needed to determine time of day when it is most beneficial for cows to consume MTB-100™ and what management practices are required to be certain all cows receive it at the most opportune time.

Table 4.1. Projected MTB-100^{TM} consumption for three periods during the grazing season.

	Period		
	1 (May 5 to July 5)	2 (July 5 to August 31)	3 (August 31 to October 2)
Treatment 1	0	0	0
Treatment 2	20	0	20
Treatment 3	0	20	0
Treatment 4	20	20	0
Treatment 5	20	20	20

Table 4.2. Ingredient composition (percent) of mineral mix projected to provide 0 or 20 g MTB-100™•cow^{-1}•d^{-1}.

	Rations[a]	
Ingredient	0 g	20 g
Southern States Mineral 2:1	98.0	48.7
Corn oil	2.0	1.3
MTB-100™	--	17.0
White salt	--	33.0

[a] Projected MTB-100™ consumption (g•cow^{-1}•d^{-1}) .

Table 4.3. Initial data for herd-managed cows and calves grazing KY-31 tall fescue and strategically supplemented with either 0 or 20 g of MTB-100™•cow^{-1}•d^{-1} (3-yr study).

	Treatment[a]				
Item	1	2	3	4	5
Cows					
Number	34	34	44	37	35
% Angus	67.6	74.4	72.2	60.4	75.2
% Beefmaster	32.4	25.6	27.8	39.6	24.8
Age, yr	6.1	6.0	5.9	5.4	5.4
Calves					
Number	34	34	44	37	35
% Angus	67.9	71.8	73.4	73.3	69.4
% Beefmaster	32.1	28.2	26.6	26.7	30.6

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

Table 4.4. Least squares means for herd-managed cow performance when grazing KY-31 tall fescue and strategically supplemented with 0 or 20 g MTB-100^{TM}•cow^{-1}•d^{-1}.

	Treatment[a]					
Collection	1	2	3	4	5	SEM
Weight, kg/cow						
May 5	505.2	495.4	499.6	507.5	510.1	7.9
Jul 5	516.0	514.3	513.1	533.6	530.1	9.0
Aug 31	521.6	517.0	525.0	547.7	543.5	12.6
Oct 2	524.8	532.6	530.2	550.5	547.5	10.4
P1 change[b]	10.8[e]	18.9[f]	13.5[e]	26.1[g]	20.0[f]	3.5
P2 change[b]	5.6	2.7	11.9	14.1	13.4	7.5
P3 change[b]	3.2[e]	15.6[f]	5.2[e]	2.8[e]	4.0[e]	3.3
BCS[c]						
May 5	4.8	4.5	4.7	4.8	5.1	0.2
Jul 5	5.1[ef]	5.1[ef]	5.0[e]	5.2[ef]	5.4[f]	0.1
Aug 31	5.0	5.1	5.1	5.3	5.6	0.2
Oct 2	5.0	5.3	5.2	5.4	5.6	0.2
P1 change[b]	0.3	0.6	0.3	0.4	0.3	0.1
P2 change[b]	-0.1	0.0	0.1	0.1	0.2	0.2
P3 change[b]	0.0	0.2	0.1	0.1	0.0	0.1
HC[d]						
May 5	8.3	8.0	7.8	8.1	7.9	0.2
Jul 5	6.2[e]	6.3[e]	6.2[e]	5.5[f]	6.4[e]	0.2
Aug 31	6.3	5.7	5.8	5.9	5.8	0.2
Oct 2	6.5	6.5	6.4	6.8	6.5	0.2
P1 change[b]	-2.1[ef]	-1.7[e]	-1.6[e]	-2.6[f]	-1.5[e]	0.3
P2 change[b]	0.1	-0.6	-0.4	0.4	-0.6	0.4
P3 change[b]	0.2[f]	0.8[e]	0.6[ef]	0.9[e]	0.7[ef]	0.2
Rectal temperature, °C						
May 5	38.9	39.1	38.9	38.8	38.9	0.1
Jul 5	39.1[ef]	39.4[e]	39.1[ef]	39.0[f]	39.3[ef]	0.2
Aug 31	38.9	38.7	38.8	38.8	38.7	0.3
Oct 2	38.4	38.6	38.6	38.4	38.6	0.2

Table 4.4. (continued) Least squares means for herd-managed cow performance when grazing KY-31 tall fescue and strategically supplemented with 0 or 20 g MTB-100^{TM}•cow^{-1}•d^{-1}.

Collection	Treatment[a] 1	2	3	4	5	SEM
P1 change[b]	0.2	0.3	0.2	0.2	0.4	0.2
P2 change[b]	-0.2[e]	-0.7[f]	-0.3[ef]	-0.2[e]	-0.6[f]	0.2
P3 change[b]	-0.5	-0.1	-0.2	-0.4	-0.1	0.4

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100^{TM}•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

[b] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f] Within a row, means without a common superscript differ ($P < 0.05$).

Table 4.5. Least square means for calf performance when nursing herd-managed cows grazing KY-31 tall fescue and strategically supplemented with 0 or 20 g of MTB-100™•cow^{-1}•d^{-1}.

	Treatment[a]					
Collection	1	2	3	4	5	SEM
Weight, kg/calf						
May 5	109.0	107.5	106.9	106.2	105.9	1.8
Jul 5	172.1	173.6	170.7	171.0	166.1	3.2
Aug 31	229.8	234.5	229.3	231.1	227.0	3.5
Oct 2	257.8	258.6	253.6	255.3	257.7	5.3
P1gain[b]	63.2[de]	66.1[d]	63.9[de]	64.7[de]	60.2[e]	1.8
P2 gain[b]	57.6	60.9	58.5	60.1	60.9	1.0
P3 gain[b]	28.0	24.1	24.4	24.2	30.7	2.2
HC[c]						
May 5	7.4	7.3	7.3	7.4	7.4	0.1
Jul 5	7.0	6.8	7.2	7.2	7.3	0.3
Aug 31	7.1[d]	6.2[e]	6.9[de]	7.2[d]	7.0[de]	0.3
Oct 2	7.7	7.4	7.7	8.0	7.8	0.2
P1 change[b]	-0.4	-0.5	-0.1	-0.2	-0.1	0.3
P2 change[b]	0.1	-0.6	-0.3	0.0	-0.3	0.3
P3 change[b]	0.6	1.2	0.8	0.8	0.8	0.2

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

[b] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[c] 1 = short hair, slick; 10 = covered with long hair.

[d, e] Within a row, means without a common superscript differ ($P < 0.05$).

Table 4.6. Least squares means for cow performance by genetic type when grazing KY-31 tall fescue in herd-managed pastures.

	Genetic type[a]				
Collection	1	2	3	4	SEM
Number	78	11	53	42	
Weight, kg/cow					
May 5	506.5	509.4	503.0	495.4	8.4
Jul 5	523.6	530.1	516.2	515.8	8.9
Aug 31	532.8	538.5	521.8	530.9	9.2
Oct 2	538.0	542.4	527.5	540.6	9.0
P1 change[b]	17.1[ef]	20.7[ef]	13.2[e]	20.5[f]	2.5
P2 change[b]	9.1[e]	8.3[ef]	5.6[e]	15.0[f]	2.5
P3 change[b]	5.2	3.9	5.8	9.7	2.3
BCS[c]					
May 5	5.0[e]	4.6[ef]	4.9[ef]	4.6[f]	0.1
Jul 5	5.2	5.1	5.1	5.2	0.2
Aug 31	5.4	5.1	5.2	5.3	0.2
Oct 2	5.5	5.2	5.2	5.4	0.2
P1 change[b]	0.2[e]	0.5[ef]	0.2[e]	0.6[f]	0.1
P2 change[b]	0.2	0.0	0.1	0.1	0.1
P3 change[b]	0.1	0.1	0.0	0.1	0.1
HC[d]					
May 5	7.9[eg]	7.4[e]	8.5[f]	8.3[fg]	0.3
Jul 5	6.8[e]	5.1[f]	7.1[e]	5.5[f]	0.3
Aug 31	6.8[e]	4.9[f]	6.6[e]	5.2[f]	0.3
Oct 2	7.5[e]	5.7[f]	7.1[e]	5.8[f]	0.2
P1 change[b]	-1.1[e]	-2.3[fg]	-1.4[eg]	-2.8[f]	0.3
P2 change[b]	0.0[e]	-0.2[ef]	-0.5[f]	-0.3[ef]	0.2
P3 change[b]	0.7	0.8	0.5	0.6	0.1
Rectal temperature, °C					
May 5	39.1[e]	38.7[f]	39.1[e]	38.9[f]	0.2
Jul 5	39.4[e]	39.0[f]	39.3[e]	38.9[f]	0.2
Aug 31	38.9[e]	38.9[f]	38.9[e]	38.7[f]	0.1
Oct 2	38.6[e]	38.4[f]	38.6[ef]	38.5[ef]	0.1

Table 4.6. (continued) Least squares means for cow performance by genetic type when grazing KY-31 tall fescue in herd-managed pastures.

	Genetic type[a]				
Collection	1	2	3	4	SEM
P1 change[b]	0.3[e]	0.3[ef]	0.2[ef]	0.0[f]	0.2
P2 change[b]	-0.4	-0.1	-0.4	-0.2	0.2
P3 change[b]	-0.3[ef]	-0.5[ef]	-0.3[e]	-0.2[f]	0.1

[a] 1 = ≥ 75% Angus ≤ 25% Beefmaster; 2 = 50% Angus 50% Beefmaster; 3 = 51 to 75% Angus, 49 to 25% Beefmaster; 4 = < 50% Angus > 50% Beefmaster.

[b] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f, g] Within a row, means without a common superscript differ ($P < 0.05$).

Table 4.7. Least squares means for calf performance by genetic type when nursing cows grazing KY-31 tall fescue in herd-managed pastures.

	Genetic type[a]				
Collection	1	2	3	4	SEM
Number	96	7	47	34	
Weight kg/calf					
May 5	109.7[d]	99.0[d]	115.7[e]	103.9[d]	3.1
Jul 5	171.1[d]	161.3[d]	183.6[e]	166.8[d]	4.2
Aug 31	226.0[d]	225.9[de]	242.6[e]	226.9[d]	5.0
Oct 2	249.6[d]	252.3[de]	269.0[e]	251.9[d]	5.3
P1 gain[b]	61.4[d]	62.3[de]	67.9[e]	62.9[d]	4.1
P2 gain[b]	54.9[d]	64.6[e]	59.0[e]	60.1[e]	1.7
P3 gain[b]	23.6[d]	26.4[de]	26.4[e]	25.0[de]	1.3
HC[c]					
May 5	7.8[d]	7.1[de]	7.2[e]	7.3[e]	0.2
Jul 5	7.9[d]	6.7[ef]	7.3[f]	6.4[e]	0.3
Aug 31	8.0[d]	6.1[ef]	7.1[f]	6.2[e]	0.3
Oct 2	8.6[d]	6.9[e]	8.1[f]	7.4[g]	0.3
P1 change[b]	0.1[d]	-0.4[de]	0.1[d]	-0.9[e]	0.2
P2 change[b]	0.1	-0.6	-0.2	-0.2	0.2
P3 change[b]	0.6[d]	0.8[de]	1.0[de]	1.2[e]	0.2

[a] 1 = ≥ 75% Angus ≤ 25% Beefmaster; 2 = 50% Angus 50% Beefmaster; 3 = 51 to 75% Angus 49 to 25% Beefmaster; 4 = < 50% Angus > 50% Beefmaster.

[b] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[c] 1 = short hair, slick; 10 = covered with long hair.

[d, e, f, g] Within a row, means without a common superscript differ ($P < 0.05$)

Table 4.8. Least squares means for cow performance by age when grazing KY-31 tall fescue in herd-managed pastures.

	Age[a]				
Collection	1	2	3	4	SEM
Number	30	17	71	66	
Weight, kg/cow					
May 5	441.8[e]	479.0[g]	542.8[f]	550.7[f]	8.5
Jul 5	455.0[e]	503.6[g]	560.9[f]	566.3[f]	9.0
Aug 31	467.4[e]	514.4[g]	569.5[f]	572.6[f]	9.2
Oct 2	475.8[e]	522.9[g]	574.7[f]	575.0[f]	9.1
P1 change[b]	13.2[e]	24.6[f]	18.1[ef]	15.6[e]	5.5
P2 change[b]	12.4[e]	10.8[ef]	8.6[ef]	6.3[f]	5.3
P3 change[b]	8.4[e]	8.5[e]	5.2[ef]	2.4[f]	5.0
BCS[c]					
May 5	4.1[e]	4.5[eg]	5.2[f]	5.3[f]	0.2
Jul 5	4.2[e]	5.0[g]	5.7[f]	5.8[f]	0.2
Aug 31	4.3[e]	5.2[g]	5.7[f]	5.8[f]	0.2
Oct 2	4.4[e]	5.4[f]	5.8[f]	5.8[f]	0.2
P1 change[b]	0.1[e]	0.5[f]	0.5[f]	0.5[f]	0.1
P2 change[b]	0.1[ef]	0.2[e]	0.0[ef]	0.0[f]	0.1
P3 change[b]	0.1[e]	0.2[e]	0.1[e]	0.0[e]	0.1
HC[d]					
May 5	9.1[e]	7.9[f]	7.5[f]	7.7[f]	0.3
Jul 5	7.8[e]	5.9[f]	5.4[f]	5.3[f]	0.3
Aug 31	6.7[e]	5.9[efg]	5.7[f]	5.2[g]	0.2
Oct 2	7.0[e]	6.7[ef]	6.3[fg]	6.1[g]	0.2
P1 change[b]	-1.3[e]	-2.0[ef]	-2.1[f]	-2.4[f]	0.3
P2 change[b]	-1.1[e]	0.0[f]	0.3[f]	-0.1[f]	0.2
P3 change[b]	0.3[e]	0.8[ef]	0.6[ef]	0.9[f]	0.2
Rectal temperature, °C					
May 5	39.4[e]	38.9[g]	38.7[fg]	38.6[f]	0.2
Jul 5	39.9[e]	39.1[g]	38.7[fg]	38.8[f]	0.2
Aug 31	39.2[e]	38.8[f]	38.7[f]	38.5[g]	0.1
Oct 2	38.7[e]	38.6[ef]	38.4[f]	38.4[f]	0.1

Table 4.8. (continued) Least squares means for performance by age groups when grazing KY-31 tall fescue in herd-managed pastures.

	Age[a]				
Collection	1	2	3	4	SEM
P1 change[b]	0.5[e]	0.2[f]	0.0[f]	0.2[f]	0.2
P2 change[b]	-0.7[e]	-0.3[f]	0.0[f]	-0.3[f]	0.1
P3 change[b]	-0.5[e]	-0.2[f]	-0.3[f]	-0.1[f]	0.1

[a] 1 = 2 yr; 2 = 3 yr; 3 = 4, 5, 6 yr; 4 = 7+ yr.

[b] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[c] 1 = emaciated; 9 = obese.

[d] 1 = short hair, slick; 10 = covered with long hair.

[e, f, g] Within a row, means without a common superscript differ ($P < 0.05$).

Table 4.9. Chemical composition of KY-31 tall fescue forage collected from herd-managed pastures (DM basis).

Collection	Treatment[a] 1	2	3	4	5	SEM
Ash						
May 5	8.8^{bc}	9.8^{b}	8.4^{bc}	8.8^{bc}	7.9^{c}	0.2
Jun 15	8.1	7.3	7.4	7.6	7.6	0.2
Jul 5	8.1^{bc}	8.6^{b}	8.2^{bc}	8.1^{bc}	7.7^{c}	0.2
Aug 31	8.8^{bc}	8.3^{bc}	8.7^{bc}	9.0^{b}	8.2^{c}	0.2
Sep 10	8.2	8.7	8.0	8.0	8.1	0.4
CP						
May 5	12.5	13.7	12.2	12.2	12.4	1.1
Jun 15	8.9	8.8	8.8	8.6	8.9	0.7
Jul 5	8.4	9.5	9.3	9.2	8.7	0.6
Aug 31	9.8	9.6	10.2	9.5	9.9	0.3
Sep 10	9.2	9.3	9.2	9.0	9.3	0.5
NDF						
May 5	51.3	50.5	50.7	51.1	49.5	0.9
Jun 15	62.8^{bc}	63.9^{b}	63.9^{b}	62.2^{bc}	61.2^{c}	0.5
Jul 5	65.3^{b}	62.0^{c}	63.9^{bc}	63.7^{bc}	63.4^{bc}	0.9
Aug 31	60.9^{b}	60.6^{b}	61.7^{b}	62.5^{bc}	64.1^{c}	0.7
Sep 10	64.5	63.4	63.4	64.2	65.8	0.9
ADF						
May 5	28.0	28.1	27.1	28.0	26.6	0.7
Jun 15	35.2	34.9	34.7	34.4	33.4	0.9
Jul 5	36.8^{b}	33.6^{c}	35.6^{bc}	35.6^{bc}	35.1^{bc}	0.9
Aug 31	31.7^{b}	31.6^{b}	32.5^{bc}	34.8^{c}	33.7^{bc}	0.7
Sep 10	36.2	34.7	34.2	35.4	36.7	0.9

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

[b, c] Within a row, means without a common subscript differ (P < 0.05)

Table 4.10. Initial data of cows and calves managed in individual plots of KY-31 tall fescue from July to October and strategically supplemented with 0 or 20 g of MTB-100™ (3-yr study).

	Treatment[a]				
Items	1	2	3	4	5
Cows					
Number	10	15	13	13	12
% Angus	93.2	82.4	83.9	86.5	86.4
% Beefmaster	6.8	17.6	16.1	13.5	13.6
Age, yr	3.8	3.7	3.5	4.0	3.9
Calves					
Number	10	15	13	13	12
% Angus	90.4	86.2	88.8	88.5	90.1
% Beefmaster	9.6	13.8	11.2	11.5	9.9

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

Table 4.11. Least squares means for performance of cows managed in individual plots from July to October and strategically supplemented with 0 or 20 g MTB-100™.

	Treatment[a]					
Collection	1	2	3	4	5	SEM
Weight, kg/cow						
May 5[b]	523.6	507.7	497.3	496.7	502.9	12.3
Jul 5	540.8	528.5	508.6	521.3	520.7	13.4
Aug 31	559.5	542.8	529.8	523.7	531.0	14.8
Oct 2	557.5	545.5	527.9	529.1	535.2	14.2
P1 change[c]	17.2^{fg}	20.8^{fg}	11.4^{f}	24.6^{g}	17.9^{fg}	4.3
P2 change[c]	18.7^{f}	14.4^{f}	21.2^{f}	2.4^{g}	10.3^{fg}	9.8
P3 change[c]	-2.0	2.7	-1.9	5.4	4.2	6.6
BCS[d]						
May 5[b]	4.9	4.7	4.5	4.5	4.7	0.2
Jul 5	5.2	5.1	4.8	5.0	5.3	0.2
Aug 31	5.4	5.2	5.1	4.8	5.3	0.2
Oct 2	5.2	5.2	4.9	4.9	5.3	0.2
P1 change[c]	0.3	0.4	0.3	0.5	0.6	0.2
P2 change[c]	0.2^{fh}	0.1^{fgh}	0.3^{c}	-0.2^{f}	0.0^{fg}	0.1
P3 change[c]	-0.2^{fg}	0.0^{fg}	-0.2^{a}	0.1^{f}	0.0^{fg}	0.1
HC[e]						
May 5[b]	8.1	8.2	8.3	7.8	8.1	0.3
Jul 5	6.3	6.2	6.4	6.1	6.3	0.4
Aug 31	6.7	6.8	6.3	6.7	6.8	0.4
Oct 2	7.4	7.9	7.3	7.1	7.8	0.3
P1 change[c]	-1.8	-2.0	-1.9	-1.7	-1.8	0.5
P2 change[c]	0.4	0.6	-0.1	0.6	0.5	0.4
P3 change[c]	0.7	1.1	1.0	0.4	1.0	0.3
Rectal temperature, °C						
May 5[b]	39.1	39.2	39.2	39.0	38.9	0.3
Jul 5	39.2	39.4	39.3	39.2	39.1	0.3
Aug 31	38.6	38.4	38.6	38.7	38.6	0.2
Oct 2	38.6^{f}	38.3^{g}	38.4^{fg}	38.3^{fg}	38.4^{fg}	0.1

Table 4.11 (continued). Least squares means for performance of cows managed in individual plots from July to October and strategically supplemented with 0 or 20 g MTB-100™.

	Treatment[a]					
Collection	1	2	3	4	5	SE
P1 change[c]	0.1	0.2	0.1	0.2	0.2	0.2
P2 change[c]	-0.6[fg]	-1.0[f]	-0.7[fg]	-0.5[g]	-0.5[fg]	0.3
P3 change[c]	0.0	-0.1	-0.2	-0.4	-0.2	0.2

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).
[b] Cows and calves were in herd-managed pastures from May 5 to Jul 5.
[c] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.
[d] 1 = emaciated; 9 = obese.
[e] 1 = short hair, slick; 10 = covered with long hair.
[f, g] Within a row, means without a common superscript differ ($P < 0.05$).

Table 4.12. Least squares means for performance of calves nursing cows when managed in individual plots of KY-31 tall fescue from July to October and supplemented with 0 or 20 g MTB-100^{TM}•cow^{-1}•d^{-1}.

Collection	Treatment[a] 1	2	3	4	5	SEM
Weight, kg/calf						
May 5[b]	110.5[e]	100.1[f]	108.2[ef]	111.9[e]	110.0[ef]	6.2
Jul 5	169.4	161.7	173.0	176.4	174.0	10.0
Aug 31	220.9	216.8	229.7	234.0	233.9	13.2
Oct 2	240.0	237.1	246.0	252.3	253.1	14.7
P1 gain[c]	58.9	61.6	64.8	64.5	64.0	4.6
P2 gain[c]	51.5	55.1	56.6	57.6	59.9	5.2
P3 gain[c]	19.1	20.3	16.3	18.3	19.2	3.2
HC[d]						
May 5[b]	7.3	7.1	7.2	7.4	6.7	0.5
Jul 5	7.5	6.8	7.1	7.4	7.0	0.5
Aug 31	7.5	6.7	6.8	7.2	6.7	0.6
Oct 2	8.5	8.0	8.3	8.0	8.0	0.5
P1 change[c]	0.2	-0.3	-0.1	0.0	0.3	0.3
P2 change[c]	0.0	-0.1	-0.3	-0.2	-0.3	0.6
P3 change[c]	1.0	1.3	1.5	0.8	1.3	0.4

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100^{TM}•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

[b] Cows and calves were in herd-managed pastures from May 5 to Jul 5.

[c] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.

[d] 1 = short hair, slick 10 = covered with long hair.

[e, f] Within a row, means without a common superscript differ (P < 0.05).

Table 4.13. Least squares means for performance of cows of two age groups and managed in individual plots of KY-31 tall fescue from July to October.

	Age[a]			
Collection	2	3	SEM	P value
Number	26	37		
Weight, kg/cow				
May 5[b]	480.1	531.1	8.4	0.01
Jul 5	495.8	552.2	9.3	0.01
Aug 31	506.3	568.5	10.3	0.01
Oct 2	510.0	568.1	9.8	0.01
P1 change[c]	15.7	21.1	3.0	0.22
P2 change[c]	10.5	16.3	3.1	0.20
P3 change[c]	3.7	-0.4	2.1	0.18
BCS[d]				
May 5[b]	4.2	5.1	0.2	0.01
Jul 5	4.7	5.4	0.2	0.01
Aug 31	4.7	5.6	0.2	0.01
Oct 2	4.7	5.5	0.2	0.01
P1 change[c]	0.5	0.3	0.1	0.43
P2 change[c]	0.0	0.2	0.1	0.17
P3 change[c]	0.0	-0.1	0.1	0.51
HC[e]				
May 5[b]	8.6	7.6	0.2	0.01
Jul 5	6.6	6.0	0.3	0.19
Aug 31	7.1	6.2	0.3	0.04
Oct 2	7.7	7.3	0.2	0.21
P1 change[c]	-2.0	-1.6	0.3	0.41
P2 change[c]	0.5	0.2	0.3	0.47
P3 change[c]	0.6	1.1	0.2	0.09
Rectal temperature, °C				
May 5[b]	39.2	38.9	0.2	0.14
Jul 5	39.4	39.1	0.2	0.80
Aug 31	38.6	38.5	0.2	0.35
Oct 2	38.5	38.3	0.1	0.10

Table 4.13 (continued). Least squares means for performance of cows of two age groups and managed in individual plots of KY-31 tall fescue from July to October.

Collection	Age[a] 2	3	SEM	P value
P1 change[c]	0.2	0.2	0.2	0.86
P2 change[c]	-0.8	-0.6	0.2	0.51
P3 change[c]	-0.1	-0.2	0.1	0.91

[a] 2 = 3 yr, 3 = 4, 5, 6 yr.
[b] Cows and calves were in herd-managed pastures from May 5 to Jul 5.
[c] P1= May 5 to Jul 5; P2 = Jul 5 to Aug 31; P3 = Aug 31 to Oct 2.
[d] 1 = emaciated; 9 = obese.
[e] 1 = short hair, slick; 10 = covered with long hair.

Table 4.14. Chemical composition of KY-31 tall fescue forage collected from individual plots (DM basis).

	Treatment[a]					
Collection	1	2	3	4	5	SEM
Ash						
Jul 5	8.4	8.2	8.5	8.4	8.4	0.2
Aug 31	8.6	8.6	8.8	8.6	8.8	0.1
Sep 10	8.3	8.2	8.6	8.5	8.3	0.2
CP						
July 5	8.9	8.7	9.1	9.5	9.1	0.3
Aug 31	9.7[bc]	9.5[b]	10.1[c]	9.5[b]	9.4[bc]	0.2
Sep 10	9.2[bc]	8.8[b]	9.7[c]	9.2[bc]	9.1[bc]	0.2
NDF						
July 5	63.4	63.8	63.5	63.1	63.8	0.6
Aug 31	64.0	64.5	62.7	64.5	64.2	0.9
Sep 10	66.5	66.4	65.1	66.1	66.4	0.6
ADF						
July 5	34.8	34.2	34.7	34.2	34.7	0.5
Aug 31	34.1	33.9	33.9	34.1	34.2	0.4
Sep 10	35.2[bc]	35.2[b]	34.0[c]	34.8[bc]	35.7[b]	0.4

[a] 1 = 0, 0, 0; 2 = 20, 0, 20; 3 = 0, 20, 0; 4 = 20, 20, 0; 5 = 20, 20, 20 g projected MTB-100™•cow^{-1}•d^{-1} in Period 1 (May 5 to Jul 5), Period 2 (Jul 5 to Aug 31) and Period 3 (Aug 31 to Oct 2).

[b, c] Within a row, means without a common superscript differ ($P < 0.05$)

Table 4.15. Weather data recorded by Williamstown, KY weather station.

Year	Month				
	May	Jun	Jul	Aug	Sep
	Avg. Maximum Temp °C				
2009	23.2[a]	27.4[a]	25.4[a]	26.8[a]	23.9[a]
2010	23.4[a]	29.1[a]	30.0[b]	31.3[b]	28.5[b]
2011	22.0[a]	27.5[a]	31.2[b]	29.4[c]	23.0[a]
	Total Precipitation (cm)				
2009	15.3	17.1	15.3	8.7	10.7
2010	17.3	19.4	7.6	2.0	0.5
2011	17.7	15.0	5.6	6.6	14.0
	Avg. Maximum Relative Humidity (%)				
2009	96.5[a]	96.6[ab]	96.6[a]	96.4[ab]	94.8[a]
2010	98.0[b]	97.6[a]	98.4[b]	97.3[a]	96.6[b]
2011	96.0[a]	96.1[b]	96.0[a]	95.9[b]	96.5[ab]

[a, b, c] Within a column, means without a common superscript differ ($P < 0.05$)

Table 4.16. Comparison of the number of days that exceeded 31°C in Experiment 1 versus Experiment 2 during July and August of each grazing season.

	No. days between 31to 35°C	No. days above 35°C	Total no. days above 31°C
Exp. 1			
Jul	45	0	45
Aug	46	11	57
Exp. 2			
Jul	36	0	36
Aug	29	1	30

Figure 4.1. Experimental timeline for 2009, 2010 and 2011.

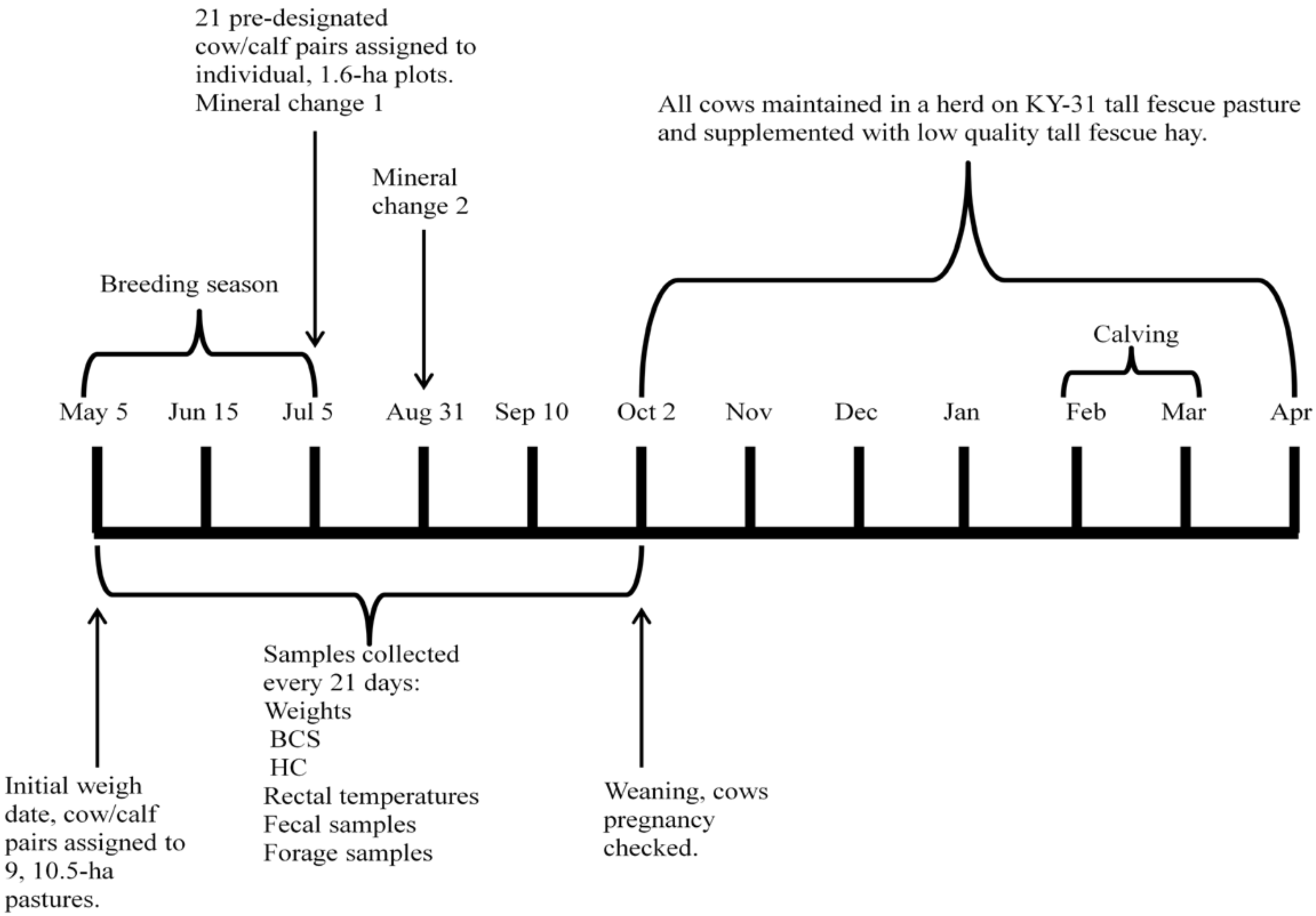


Figure 4.2. Ergovaline content (ppm) of KY-31 tall fescue forage grazed by herd managed cows and calves strategically supplemented with MTB-100™ projected to be consumed at a rate of 0 or 20 g•cow^{-1}•d^{-1}.

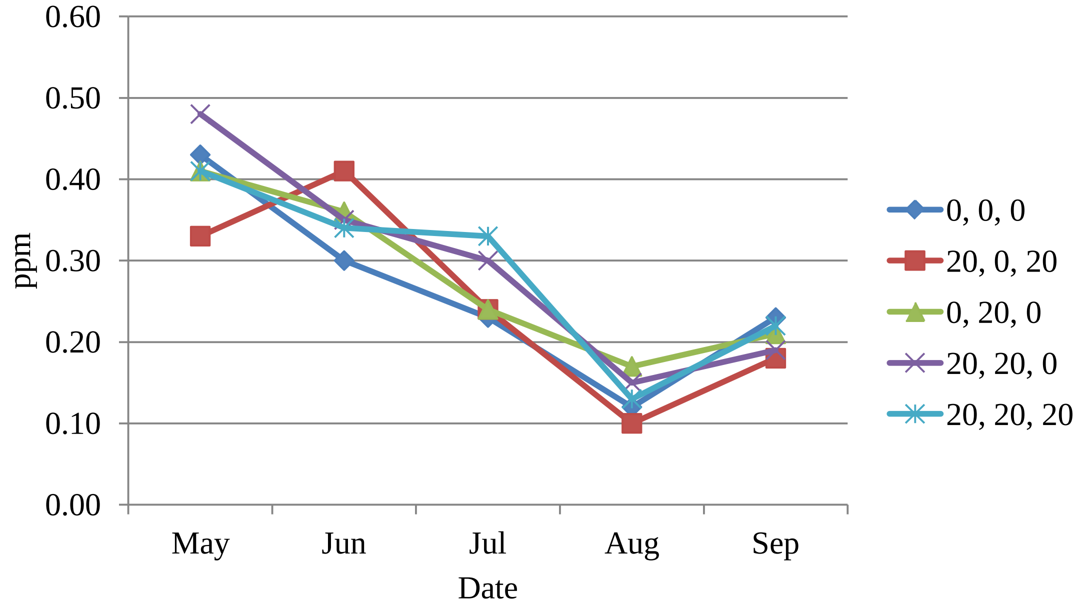


Figure 4.3. Lysergic acid content (ppm) of KY-31 tall fescue forage grazed by herd managed cowsand calves strategically supplemented with MTB-100™ projected to be consumed at a rate of 0 or 20 g•cow^{-1}•d^{-1}.

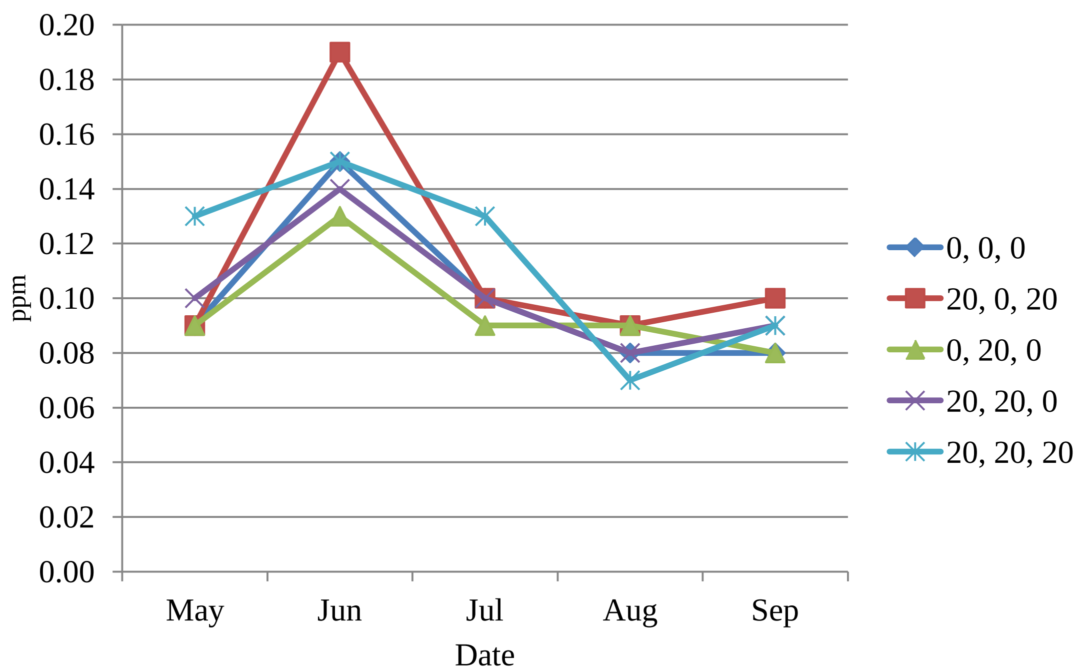


Figure 4.4. Ergovaline content (ppm) of fecal samples collected from herd managed cows grazing KY-31 tall fescue and strategically supplemented with MTB-100™ at projected rates of 0 or 20 g•cow^{-1}•d^{-1}.

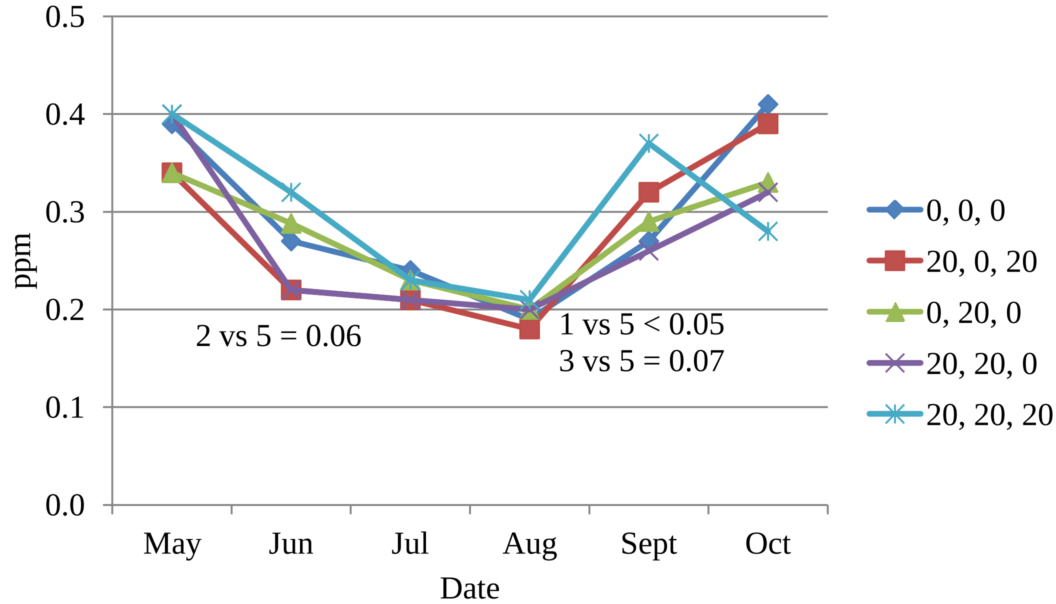


Figure 4.5. Lysergic acid content (ppm) of fecal samples collected from herd managed cows grazing KY-31 tall fescue and strategically supplemented with MTB-100™ at projected rates of 0 or 20 g•cow^{-1}•d^{-1}.

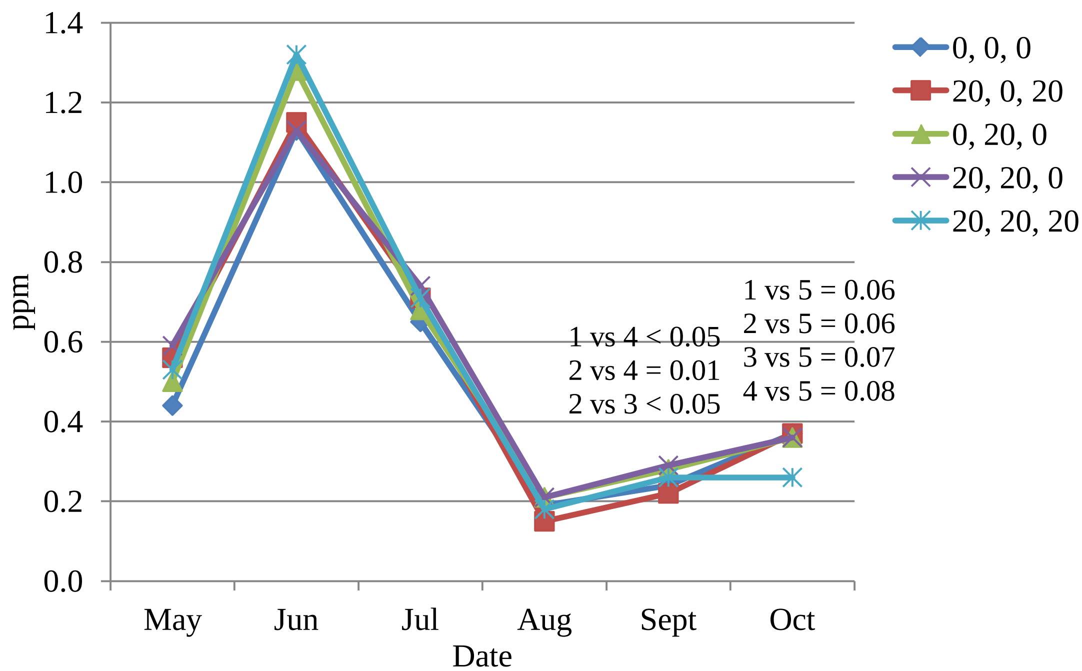


Figure 4.6. Ergovaline content (ppm) of individual plots of KY-31 tall fescue forage grazed by cows and calves strategically supplemented with 0 or 20 g MTB-100™•cow^{-1}•d^{-1}.

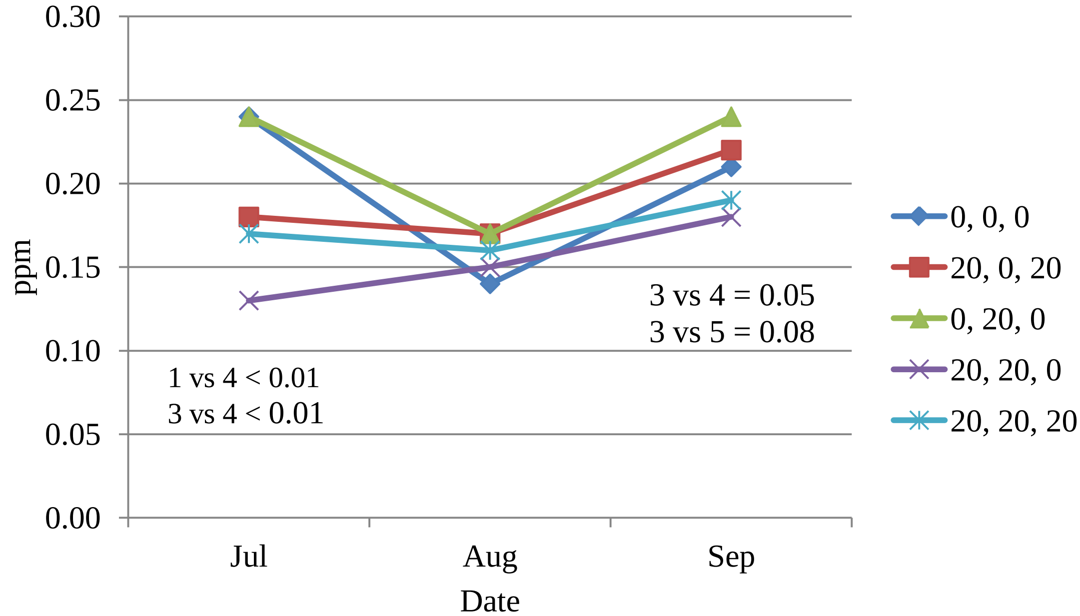


Figure 4.7. Lysergic acid content (ppm) of individual plots of KY-31 tall fescue forage grazed by cows and calves strategically supplemented with 0 or 20 g MTB-100™•cow^{-1}•d^{-1}.

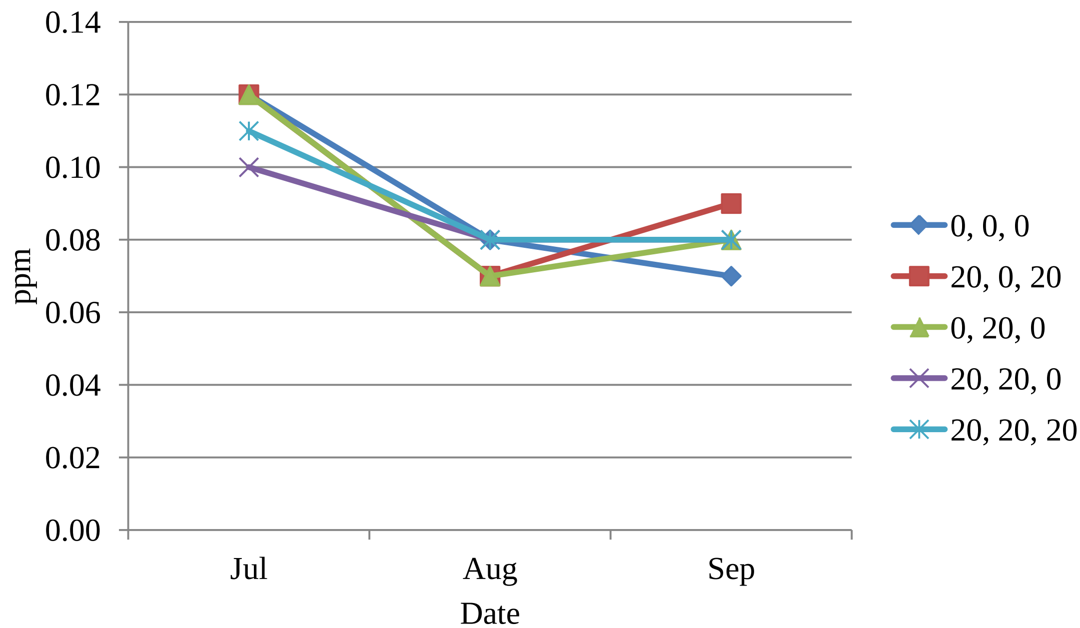


Figure 4.8. Ergovaline content (ppm) of fecal samples collected from cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to October, and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g MTB-100™•cow^{-1}•d^{-1}.

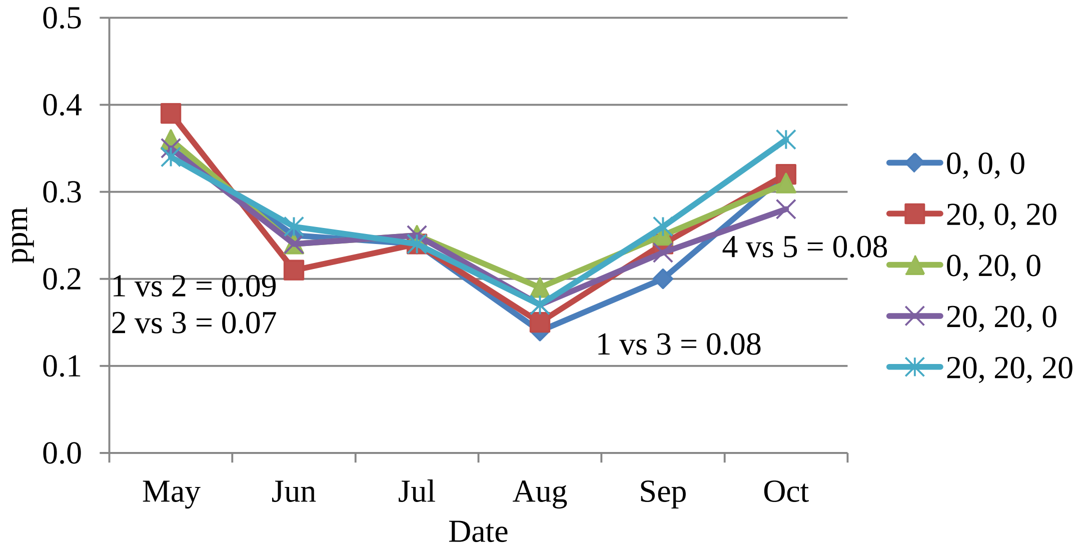


Figure 4.9. Lysergic acid content (ppm) of fecal samples collected from cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to October, and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g MTB-100™•cow^{-1}•d^{-1}.

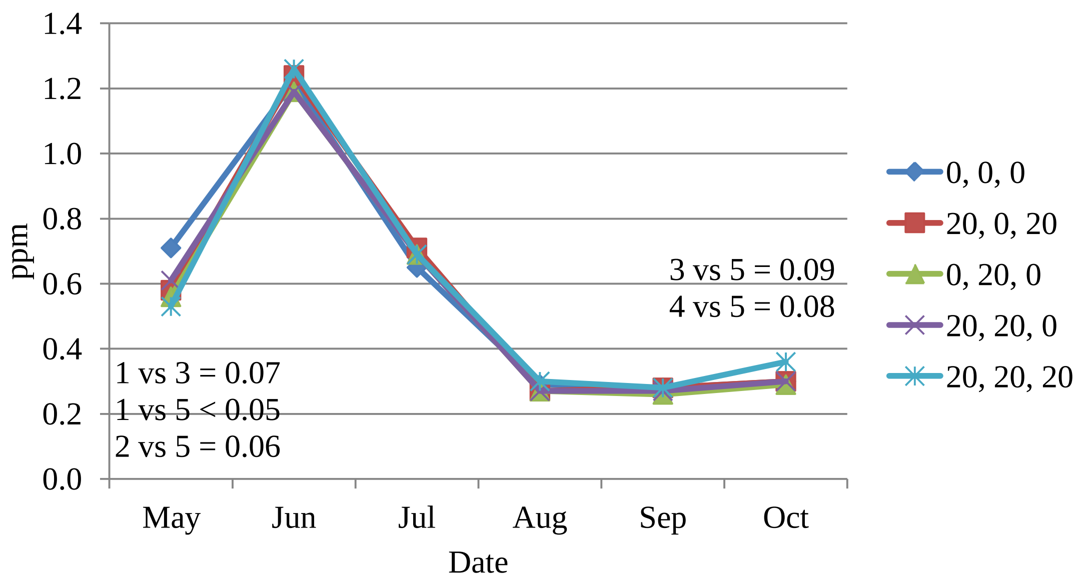


Figure 4.10. Daily mineral mix consumption (g/cow) of herd managed cows and calves grazing KY-31 tall fescue and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g•cow^{-1}•d^{-1}.

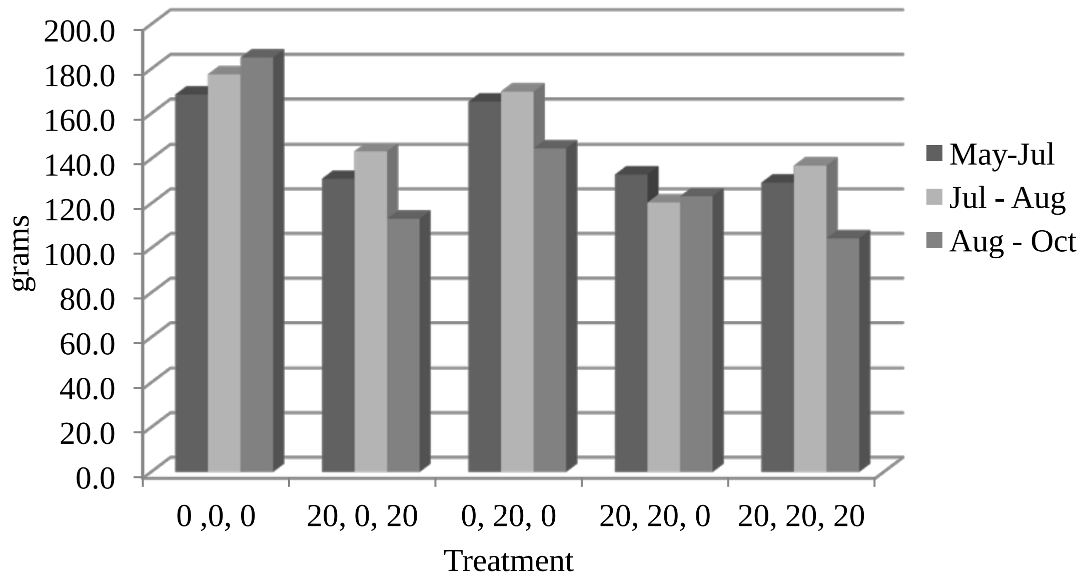


Figure 4.11. Daily MTB-100™ consumption (g/cow) of herd managed cows and calves grazing KY-31 tall fescue and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g•cow^{-1}•d^{-1}.

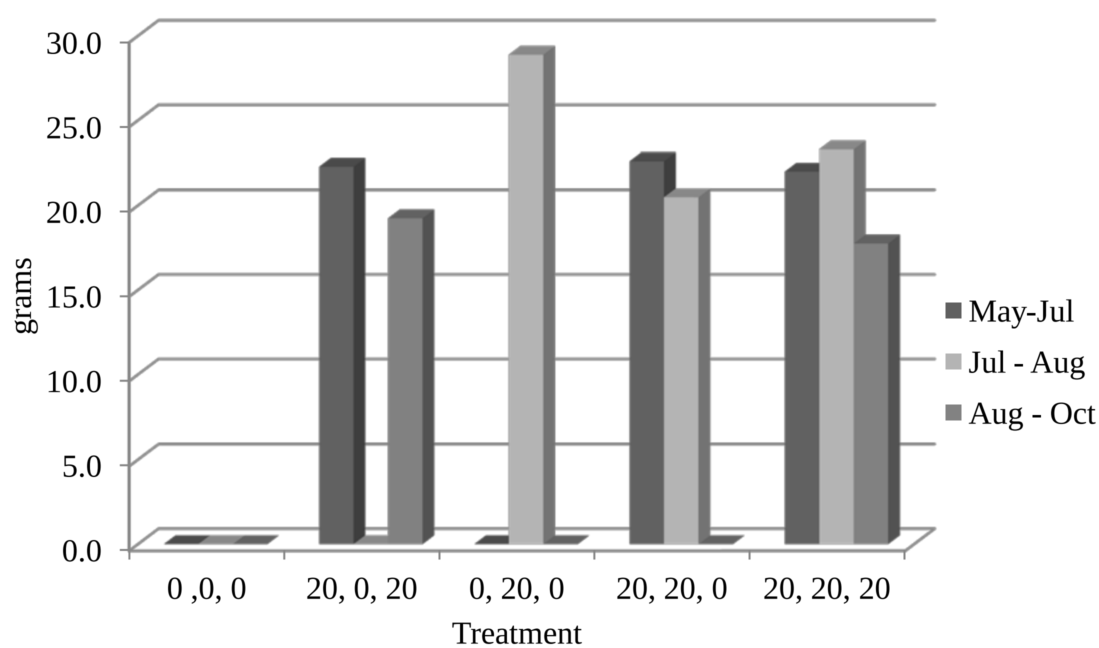


Figure 4.12. Daily mineral mix consumption (g/cow) of cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to October, and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g•cow^{-1}•d^{-1}.

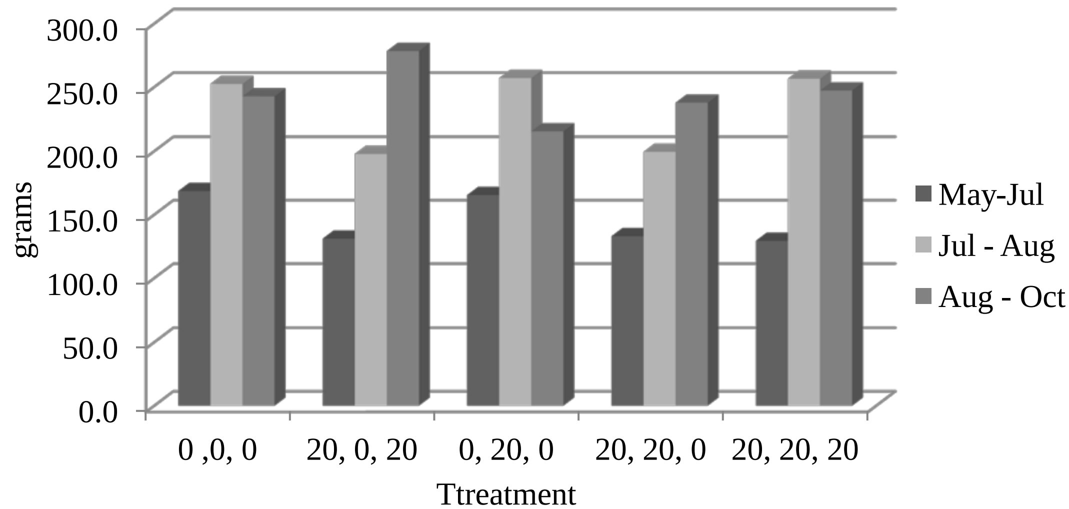


Figure 4.13. Daily MTB-100™ consumption (g/cow) of cows grazing KY-31 tall fescue in herds from May to July, in individual plots from July to October, and strategically supplemented with MTB-100™ at projected consumption rates of 0 or 20 g•cow^{-1}•d^{-1}.

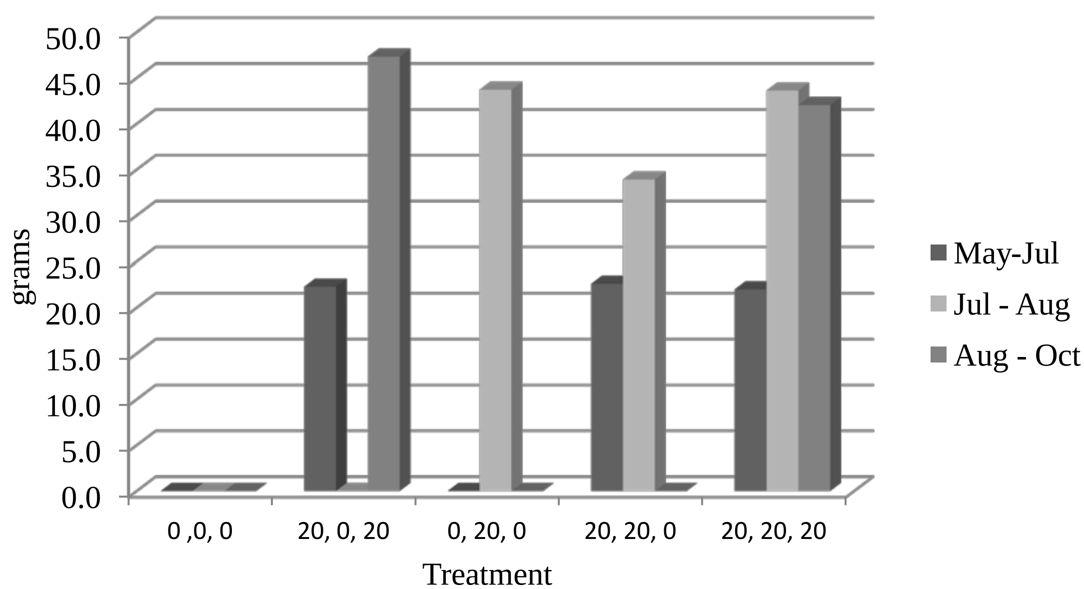


Figure 4.14. Comparison of total rainfall per month and concentration of ergovaline (EV) in KY-31 tall fescue forage collected on specific dates within each month.

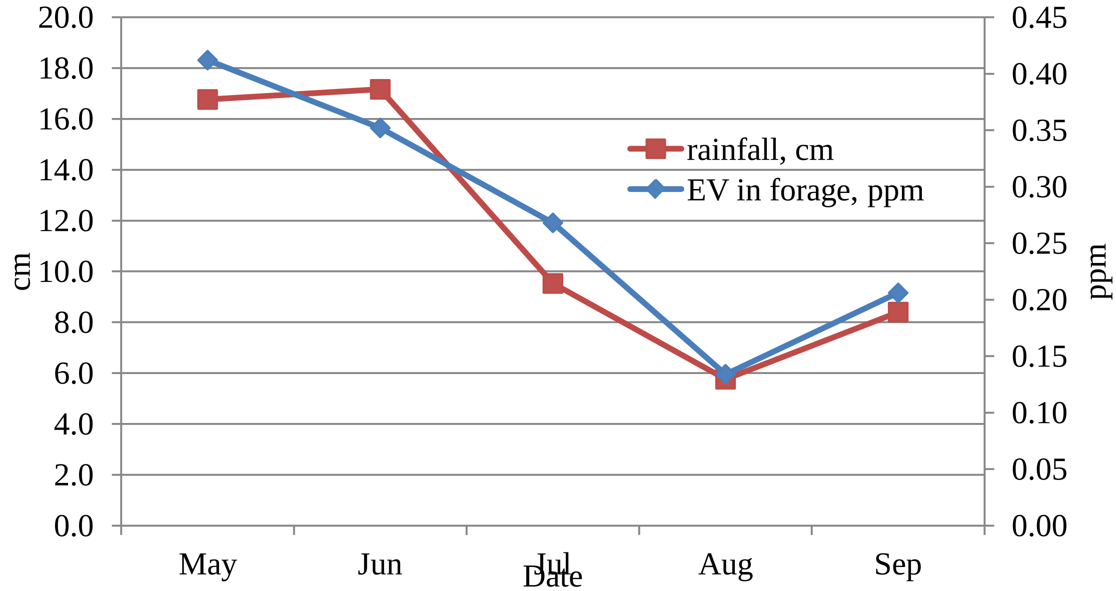
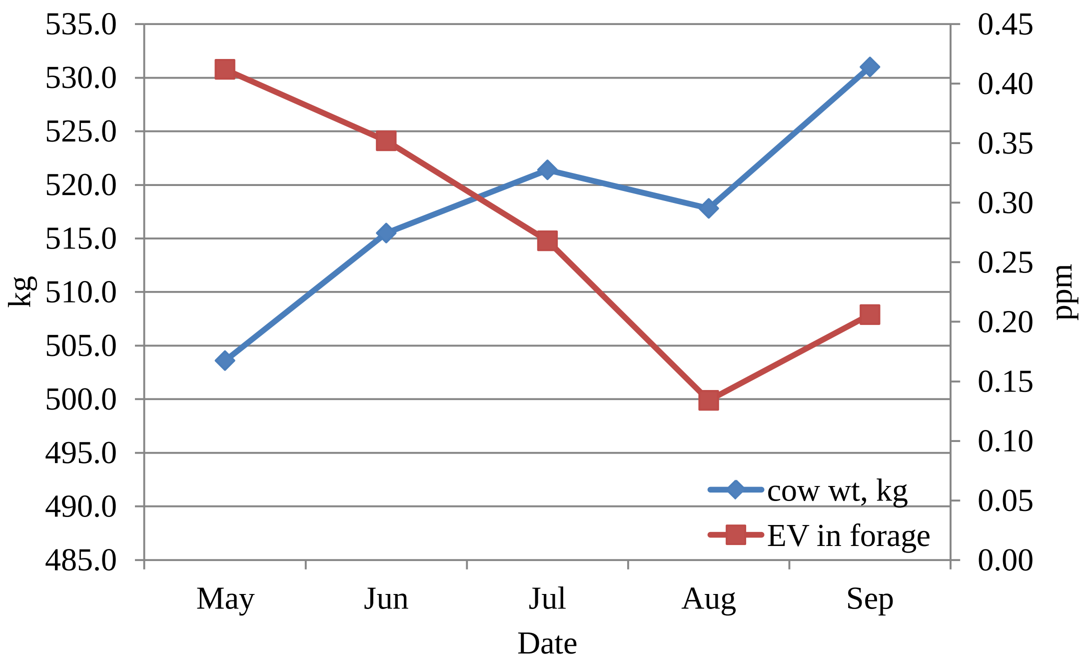


Figure 4.15. Comparison of cow weights and concentrations of ergovaline (EV) in KY-31 tall fescue forage during the grazing season.



CHAPTER V

General Summary and Implications

Weather trends were similar between experiments with the cooler ambient temperatures occurring early (May) and late (September) during the grazing season and the largest amount of rainfall occurring in May and June, declining in July and August and increasing again in September. However, when comparing weather data between Exp. 1 and 2, it was found the weather in Exp. 1 had more potential to cause heat induced fescue toxicity due its higher ambient temperatures in July and August and higher concentrations of EV in the pastures.

Providing MTB-100^{TM} in an ad libitum access mineral mix did not have an effect on cow/calf performance in Exp. 1. One reason for this may be due to the lack of control of MTB-100^{TM} intake. In both experiments, mineral and, therefore, MTB-100^{TM} consumption did not meet the projected levels, and it could not be determined if every cow in the herd-managed pastures consumed it. Evans and Dawson (2007) demonstrated it takes 1.5 hours of incubation for the yeast cell wall product to bind ergotamine. It may be more beneficial to the animal if MTB-100^{TM} is consumed prior to grazing endophyte-infected tall fescue than at random times throughout the day. Experiment 2 did show improvement of cow performance when MTB-100^{TM} was consumed earlier in the grazing season when ergot alkaloid concentrations were highest in the pasture. The difference in results from Exp. 1 and 2 could possibly be attributed to environmental impact on Exp. 1 herd-managed cows not wanting to leave the shade under extreme temperatures to consume mineral. Placement of mineral feeders by the water source in individual plots may have enticed cows to consume mineral and would explain the excessive consumption of MTB-100^{TM}. However, herd-managed pastures were shaded and had other water sources such as a pond or a stream located in a different area of the 10.5-ha pasture than the mineral feeder. Individual plots were more uniform so cows had no shade and the same fresh water source but cows could not be assigned to these plots until after breeding season which occurred at the same time as peak EV concentration in the pasture. By this time, MTB-100^{TM} supplementation may not be as beneficial.

Since Exp. 2 grazing season did not have as many days that exceeded 31°C than Exp. 1, cows may have spent less time idling and were more eager to go to the mineral feeders regardless of its location. Another reason for differences found between experiments could be explained by removing the 2010 and 2011 heifer data from Exp. 2. Experiment 1 determined fescue toxicity was more severe in young cows. Thus, susceptibility to fescue toxicity could influence the young cows behaviors, making them want to spend more time in shaded areas or stand in a pond than grazing or going to the mineral feeder. This could mask true effects of supplementation on other cows that may have spent more time grazing or consumed more of the mineral mix.

When the strategic supplementation experiment was designed, the alternating MTB-100^{TM} treatments were to be in 2-month increments. For example, Treatment 2 was developed so cows received 20 g of MTB-100^{TM}•cow^{-1}•d^{-1} in May and June, 0 g in July and August and 20 g in September and October each year. However, due to unforeseen circumstances in weather of 2010, the grazing season could not be extended through the entire month of October so calves were weaned earlier than normal. Therefore, the periods when MTB-100^{TM} was provided had to be re-evaluated prior to the following grazing season which ended on Oct 2.

Despite genetic type and age having an impact on cow performance, these factors did not have an influence on treatment because all ages and breeds were equally distributed across treatments and cows in each group responded the same way independent of treatment. The herd used in these experiments has been maintained on this farm for many years and it is possible that these cows have adapted to these tall fescue pastures. It would have been ideal to bring in a naive set of cows into this herd while using the same strategic supplementation scheme to elicit a bigger response to treatment.

In a production setting, some methods of supplementing beef cows with a glucomannan to ensure appropriate consumption that will exhibit improvement in animal performance may not be economically feasible. Therefore, these experiments were conducted to determine if an optimal level of supplementation and a management practice that would provide it with minimum labor would benefit animal performance. In doing so, it became obvious many variables cannot be controlled in a practical situation which could prevent MTB-100™ from being effective in alleviating some or all of fescue toxicity. Some of these variables are pasture layout, mineral mix consumption and weather variation from one season to the next. However, the result of Exp. 2 show, from a producer's standpoint, MTB-100™ has potential to alleviate some fescue toxicity especially when provided during breeding in May and June as well as during the hottest months of July and August. Additional research may be able to determine if time of day and frequency of MTB-100™ consumption can be more beneficial to the animal by alleviating symptoms of fescue toxicity and, thus, improve performance of all cows in the herd.

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